CADDO LAKE
A Unique Wetland Ecosystem

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A Delineation of Resource Category 1 Habitat
under the
U.S. Fish and Wildlife Service
Mitigation Policy

U.S.
FISH & WILDLIFE
SERVICE
DEPARTMENT OF THE INTERIOR

U.S. Fish and Wildlife Service
Ecological Services
Arlington, Texas

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Acknowledgements and Concurrence

The following report and resource category delineation were prepared by Tom Cloud, Senior Staff Biologist, of the Arlington, Texas, Ecological Services Field Office. It was reviewed and approved by Robert M. Short, Field Supervisor.

In accordance with current U.S. Fish and Wildlife Service directives and guidance, this delineation has also been reviewed and approved by the Regional Directorate of the Southwest and Southeast Regional Offices located in Albuquerque, New Mexico and Atlanta, Georgia, respectively.

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The objective of this report is to document the unique fish and wildlife attributes of the Caddo Lake ecosystem and provide a delineation of its resource category for future planning efforts by Federal, State, and Regional agencies and private entities. It is hoped that this delineation by the U.S. Fish and Wildlife Service will provide a basis for the recognition of the region's high environmental values and serve as a catalyst for preservation of this significant fish and wildlife resource.

Background

On January 23, 1981, the U.S. Fish and Wildlife Service (Service) published its final policy guidance for Service personnel involved in making recommendations to protect or conserve fish and wildlife recources (U.S. FWS 1981). The purpose of this Mitigation Policy was to lend consistency to Service recommendations nationwide and to allow other public and private entities some ability to anticipate the scope of potential Service recommendations and to plan their mitigation activities accordingly.

The major concept behind the Mitigation Policy is the need to identify and protect our most important and valuable fish and wildlife habitats while facilitating balanced development of the Nation's natural resources. As noted in the policy, the guidance applies only to Service employees involved in providing mitigation recommendations, and does not dictate the actions or positions that other Federal action agencies or individuals must accept. It is hoped, however, that the policy will be strongly considered by other parties in the formulation of mitigation actions and in their decision-making process.

The primary focus of the Mitigation Policy is on the prevention or mitigation of the losses of habitat value which can occur as a result of the development of natural resources. It is based on the concept that avoidance or compensation should be recommended for the most valuable fish and wildlife resources and the degree of mitigation requested should correspond to the value and scarcity of the resource on a national or ecoregion basis. Four different "resource categories" have been delineated in the policy using these criteria along with corresponding mitigation planning goal6 which should be pursued for each category (Table 1).

Table 1. Resource categories and mitigation planning goals.

RESOURCE CATEGORY	DESIGNATION CRITERIA	MITIGATION PLANNING GOAL
1	High value for evaluation species and unique and irreplaceable.	No loss of existing habitat value.
2	High value for evaluation species and scarce or becoming scarce.	No net loss of in-kind habitat value.
3	High to medium value for evaluation species and abundant.	No net loss of habitat value while minimizing loss of in-kind habitat value.
4	Medium to low value for evaluation species.	Minimize loss of habitat value.

Area of Consideration

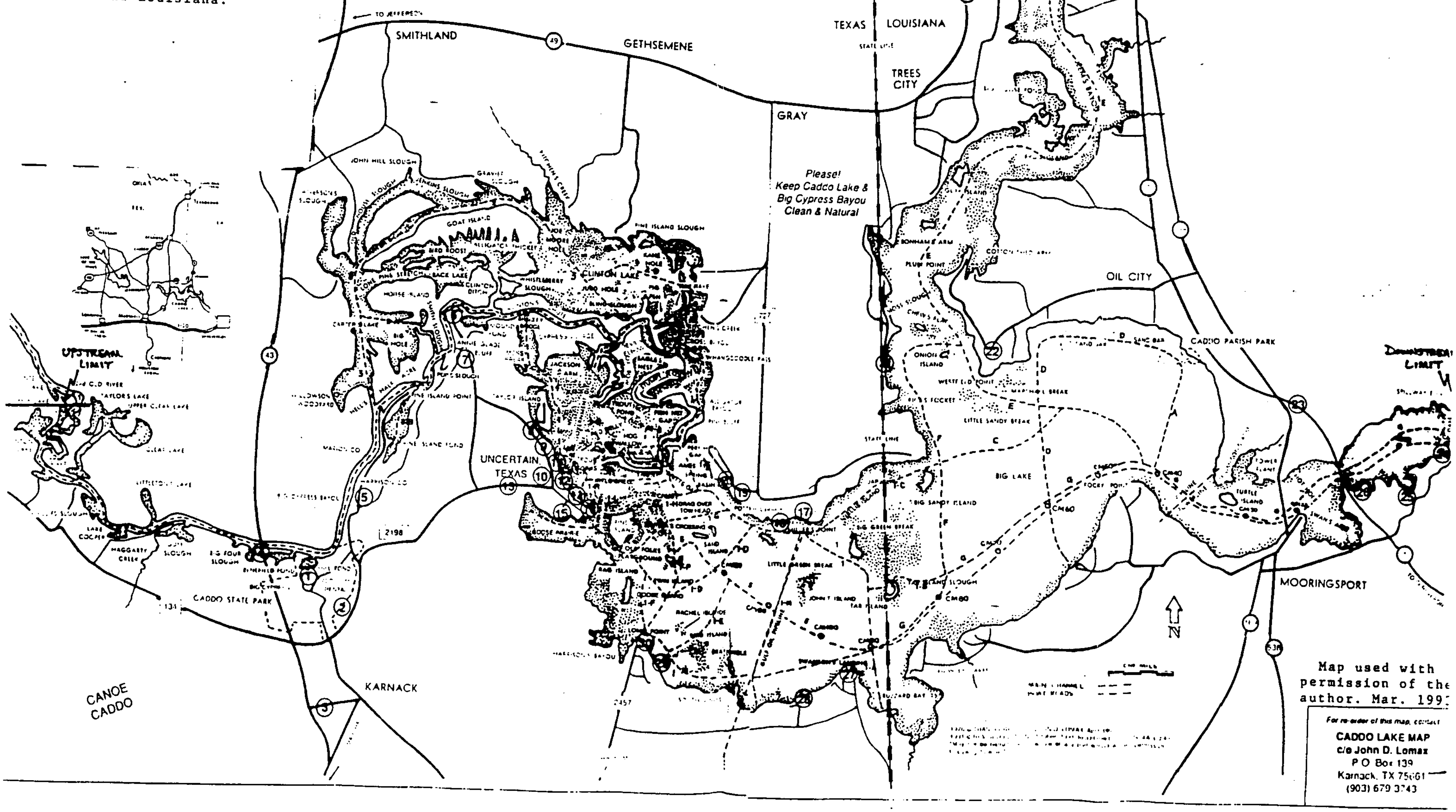
The specific area considered in this resource category delineation is identified in Figure 1. It basically consists of the following:

1. Caddo Lake (spillway elevation 168.5 ft. msl) and its shoreline beginning at Caddo Lake Dam and proceeding upstream on Big Cypress Bayou to the vicinity of Stumpy Lake west of Highway 43; and

2. Associated backwaters, sloughs, cypress swamps, and bottomland hardwood forests to approximately elevation 175.0 ft. msl.

It is recognized that activities in Louisiana (e.g., dam and water level modifications) could also impact important fish and wildlife habitats in the Texas portion of the lake. Therefore, the Service's designation also includes that portion of the lake within the State of Louisiana. Future water resource planning projects should give serious consideration to the protection of Caddo Lake as an integrated, high quality ecosystem.

Figure 1. Area designated as Resource Category 1, Caddo Lake, Texas and Louisiana.



Technical Rationale for Resource Category Classification

As noted above, two major factors are considered by the Service in determining the resource category of a fish and wildlife habitat. These include the value of the habitat to representative fish and wildlife species and the relative abundance of the habitat on a regional or national basis. In the case of the highest-valued habitats (i.e., Resource Category 1), uniqueness and replaceability of the habitat are considered more important than abundance.

Habitat Value

Terrestrial and wetland habitats at Caddo Lake were evaluated for their importance to a variety of wildlife species of national and regional significance. These included waterfowl (wood duck and mallard), Neotropical migratory birds (parula, yellow-throated, cerulean and prothonotary warblers), restricted wetland species (American alligator and river otter), and resident wildlife, such as barred owl, gray squirrel, beaver, and green heron. Aquatic habitats were evaluated for their importance to the most significant gamefish species, largemouth bass and white and black crappie.

Several studies of Caddo Lake's wetlands and associated terrestrial habitats have documented their high value to the evaluation species. In 1981, the Service initiated a study to identify and characterize bottomland hardwood tracts in east Texas having significant waterfowl resource values. This study culminated in 1985 with the listing of 62 priority sites (U.S. Fish and Wildlife Service 1985). Upper Caddo Lake and Big Cypress Bayou in the lake's headwaters were identified in this study as significant waterfowl habitats, and received a Priority 1 ranking for potential acquisition. These areas were also recognized for their high value to other important species such as furbearers, colonial waterbirds, other migratory birds, raptors, and game species.

Subsequent to the Service's study, the Texas Parks and Wildlife Department in cooperation with The Nature Conservancy has begun acquisition of the upper Caddo Lake area in order to protect and preserve its extremely high environmental quality. These organizations have determined that Caddo Lake supports some of the highest populations of wood ducks and mallards in the State of Texas, with portions of upper Caddo considered possibly the premier wood duck production habitat in the state. According to the Department, prior to development and law enforcement problems at Caddo Lake, it rivaled Stutgart, Arkansas, as a famous duck hunting location. Their evaluations have also identified Caddo Lake as an historic concentration area for a variety of other migratory waterfowl, nongame birds, and resident wildlife species.

Field surveys conducted by the Service in conjunction with proposed water resource development projects in the area have similarly confirmed the high value of wetlands at Caddo Lake for migratory and wetland species. Habitat values of representative bottomland hardwood and baldcypress swamp wildlife species, such as wood duck, barred owl, gray squirrel, beaver and green heron, were all near optimum values. This is primarily the result of the quality of the habitat in the area which is characterized by relatively mature mast-bearing hardwoods, dense canopy cover, diversity of understory vegetation, and an abundance of snags, cavities, and other wildlife nesting and refuge sites. The mature hardwood6 within the Caddo Lake area are especially vital to the survival and productivity of the Neotropical migrant birds, providing critical nesting habitat during the spring and summer breeding season. The prothonotary warbler requires cavities which occur in the cypress and hardwood trees for nesting, while the cerulean warbler commonly occupies the canopy of the tallest trees. The parula and yellow-throated warblers are dependent upon Spanish moss in the cypress canopy for nesting material. All of these wood warblers are very specific in their habitat requirements and need large, relatively undisturbed tracts of forested woodlands for optimum habitat conditions.

The extent and quality of baldcypress swamps, emrgent wetlands, and shallow vegetated flats in Caddo Lake make it an excellent habitat for restricted wetland species such as the American alligator and river otter. These habitats provide abundant food for these species, including fish, crayfish, turtles, frogs, snakes, birds, small mammals, and invertebrates. Cypress stump logs, debris, bare clay banks and other littoral cover are abundant within the wetlands of Caddo Lake and Cypress Bayou and provide plentiful denning sites for these species as well. According to Texas Parks and Wildlife Department, the river otter population of Caddo Lake may be the densest in Texas.

Surveys of Caddo Lake indicate that it supports Texas' most diverse fish fauna, with 69 species collected in one study (Gray 1955). The lake and Big Cypress Bayou provide a variety of aquatic habitats, consisting of shallow, heavily vegetated open water; sluggish flowing bayous with numerous snags, logs, and stumps; oxbows; sloughs; and backwaters. The area has been characterized by TPWD as the epitome of fish habitat and supports high populations of largemouth bass, black and white crappie, channel catfish, bluegill and other species (Toole and Ryan 1981).

In addition to the important gamefish species, Caddo Lake supports. a variety of less common and specialized fish species such as paddlefish, American eel, bowf in, southern brook lamprey, chain pickerel, flier, and bantam sunfish (Hike Ryan, personal communication). Most of these species are at the periphery of their western range and their distribution is generally restricted to the large rivers, sloughs, and backwaters of eastern Texas (Lee et al. 1980). Impoundment of free-flowing rivers and streams has altered the habitat of these species and restricted their movement to preferred spawning areas. Species like the American eel have been particularly effected, since they breed and spawn in the sea and upstream migrations have been blocked by dams and pollution sources.

Based on the studies and information summarized above, it is apparent that Caddo Lake and its headwatus along Big Cypress Bayou provide outstanding and highly productive fish and wildlife habitats.

Habitat Availability

Several studies have documented the increasing scarcity of bottomland hardwood forests, and their associated wetland habitats, within Texas and the nation (Rayu et al. 1983, U.S. FWS 1985, Frye 1987). In Texas, Landsat satellite images have been compared to historic records of the extent of bottomland forest communities, and it has been estimated that approximately 63 percent of these communities have been lost due to forestry practices, water resource developments, and othu human activities (Rye 1987). The studies also indicated that significant future losses could be expected to occur due to increasing development pressures on the resource.

More recent efforts by Texas Parks and Wildlife Department to preserve the fragile ecosystem of Caddo Lake have noted that there are only half a dozen large baldcypress-tupelo wetland sites left in Texas, *comprising* less than 95,000 acres (TPWD 1991a). Caddo Lake is one of the largest remaining tracts of this wetland type, and it is rapidly being impacted by timber harvest, oil and gas production, and homesite development.

The limited distribution of cypress swamps (i.e., forested wetlands) and bottomland hardwood forests in Texas, and the rapid rate at which these important wildlife resources are being developed, indicates that they have a high resource value and should be given priority consideration for preservation.

Uniqueness and Replaceability of the Habitat

Without question, Caddo Lake is one of the most biologically diverse areas in Texas. It is host to the state's most diverse, native, freshwater fish fauna. It is also considered either home or potential habitat for at least 44 animals, plants, or plant communities considered endangered, threatened, or rare by Texas Parks and Wildlife Department (TPWD 1991a). The Texas Natural. Heritage Program *of the* Department indicates that ten of these species occur at five or fewer locations in Texas (Attachment 1).

Studies on vatu resource projects within the basin indicate that the forested wetlands of the area provide habitat for approximately 216 species of birds, 47 mammals, and 90 reptiles and amphibians (U.S. Army Corps of Engineers 1986, TPWD 1991b). The backwaters of Caddo Lake provide refuge for migratory waterfowl, breeding areas for colonial waterbirds, and support some of the highest densities of furbearing animals in the state.

In addition to wildlife species, Caddo Lake and its associated baldcypress swamp and flooded hardwood forest comprise one of the most floristically diverse areas in the state (Campo 1986). Inventories of east Texas hardwood bottomlands, including Caddo Lake, indicate that they support at least 189 species of trees and shrubs, 42 woody vines, 75 grasses, and 802 other herbaceous plants. Of these, 73 species are considered to be of special concern in east Texas and 48 of them are found in or in most cases restricted to hardwood bottomlands and associated wetlands (U.S. FWS 1985, Hayes 1987).

Bottomland hardwood forests, especially forested wetlands such as the baldcypress swamps of upper Caddo Lake, are very fragile because of their limited distribution and restrictive site requirements. Baldcypress cannot regenerate on a flooded substrate, and the seedlings will not tolerate prolonged complete submergence. Mature cypress have survived in Caddo Lake since their permanent inundation; however, their growth and vigor is usually restricted with greater mortality occurring in the deeper sections of the lake. Previous studies specific to Caddo: Lake have documented the effect of water level changes on the baldcypress stands. These studies indicate that baldcypress are able to persist during changes in hydrological regimes, but growth, reproduction, and survival are directly related to the frequency of substrate exposure (Klimas 1987).

Under the current operating regime of Caddo Lake, with its water level stabilized at 168.5 ft. msl by an uncontrolled spillway, there is little cypress regeneration occurring. Thus, any restoration potential for impacted stands of baldcypress would be limited due to the inability to draw the lake down and provide exposed substrates for the tree's establishment.

Similarly, the stabilized water levels of Caddo Lake have also restricted the establishment of many hardwood species which are unable to tolerate frequently flooded sites. Viable hardwood stands would be difficult or impossible to reestablish on the periphery of the lake and low islands due to frequent inundation and soil saturation during the growing season.

Without some ability to control water elevations in Caddo Lake, it would not be technically possible to replace or restore impacted forested wetlands. Even if successful seedling development were to. occur during a period of lake decline, the frequent, prolonged spring flooding which occurs within the lake's basin would result in the death of most of the seedlings. Those that did survive would require many years to mature and provide habitat features comparable to those which now occur at the lake.

Resource Category Designation

The above discussions clearly identify Caddo Lake and its forested wetlands as a unique and extremely high quality fish and wildlife habitat of limited accurrence. These wetlands are also very fragile due to their exacting environmental requirements and cannot be restored using current technology. Restoration potential is further constrained by the lack of water level control available at Caddo Lake.

The combination of Caddo Lake's high-valued habitat, uniqueness, and lack of replaceability of inkind habitat values indicates that it should be classified as a Resource Category 1. The future goal of the Service will be to seek no loss of existing habitat value on those activities which could adversely impact this valuable resource. Efforts should be directed toward the avoidance of any significant adverse impact, while allowing compatible development actions to continue within the designated area.

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TABLE 1
THE CADDO LAKE PROJECT
RARE PLANT AND ANIMAL SPECIES AND NATURAL COMMUNITIES
(Compiled by Tom Hayes, Texas Nature Conservancy)

(Source: Texas Parks and Wildlife, 1991a)

Common Name	Scientific Name	Occurrence	TNC RANK	TNHP/TOES/ State/Federal/ Rank
Mammals				
River Otter	*Lutra canadensis*	C	G5S3	SC,T
Southeastern Myotis	*Myotis austroriparius*	C	G4?S3	SC,WL,ST,C2
Little Brown Myotis	*Myotis lucifugus*	C	G5S3	SC
Eastern Big-eared Bat	*Plecotus rafinesquii*	C	G4S4	SC,T,ST,C2
Black Bear	*Ursus americanus*	P	G5S3	SC,T,SE,FPT
Birds				
Bachman's Sparrow	*Aimophila aestivalis*	C	G3S2	SC,WL,ST,C2
Roseate Spoonbill	*Ajaia ajaja*	C	G5S4	SC
Golden Eagle	*Aquila chrysaetos*	P	G4S?	WL
Piping Plover	*Charadrius melodus*	C	G2S?	SC,T,ST,FT
Fish Crow	*Corvus ossifragus*	C	G5S4	SC
American Swallow-tailed Kite	*Elanoides forficatus*	C	G5S2	SC,T,ST
Merlin	*Falco columbarius*	C	G4S?	T
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	P	G3T1S1	SC,T,ST,FT
Bald Eagle	*Haliaeetus leucocephalus*	C	G3S2	SC,E,SE,FE/T
Worm-eating Warbler	*Helmitheros vermivorous*	C	G5S3	SC
Wood Stork	*Mycteria americana*	C	G5S?	T,ST,FE
Osprey	*Pandion haliaetus*	C	G5S3	SC
Red-cockaded Woodpecker	*Picoides borealis*	P	G2S2	SC,E,SE,FE
White-faced Ibis	*Plegadis chihi*	C	G4S2	SC,T,ST,C2

TABLE 1 (continued)
THE CADDO LAKE PROJECT
RARE PLANT AND ANIMAL SPECIES AND NATURAL COMMUNITIES

Common Name	Scientific Name	Occurrence	TNC RANK	TNHP/TOES/ State/Federal/ Rank
Reptiles and Amphibians				
American Alligator	Alligator mississippiensis	C	G5S4	WL,FT
Mole Salamander	Ambystoma talpoideum	C	G5S3	SC,WL
Northern Scarlet Snake	Cemophora coccinea copei	C	G5T5S3	WL,ST
Southern Painted Turtle	Chrysemys picta dorsalis	C	G5T5S1	SC
Canebrake Rattlesnake	Crotalus horridus atricaudatus	P	G5S?	T,ST
Milk Snake	Lampropeltis triangulum	C	G5S?	WL
Alligator Snapping Turtle	Macroclemys temminckii	C	G3?S3	SC,T,ST,C2
Texas Horned Lizard	Phrynosoma cornutum	C	G5S5	SC,T,ST,C2
Louisiana Pine Snake	Pituophis melanoleucus ruthveni	P	G5T3S2	SC,E,SE,C2
Fishes				
Blue Sucker	Cycleptus elongatus	P	G4S3	SC,ST,C2
Creek Chubsucker	Erimyzon oblongus	C	G5S2S3	SC,ST
Ironcolor Shiner	Notropis chalybaeus	C	G5S3	T
Bluehead Shiner	Notropis hubbsi	C	G3S1	SC,T,ST
Taillight Shiner	Notropis maculatus	C	G5S1	SC,T
Blackside Darter	Percina maculata	C	G5S?	T,ST
Paddlefish	Polyodon spathula	P	G4S1	SC,T,SE

TABLE 1 (continued)
THE CADDO LAKE PROJECT
RARE PLANT AND ANIMAL SPECIES AND NATURAL COMMUNITIES

Common Name	Scientific Name	Occurrence	TNC RANK	TNHP/TOES/ State/Federal/ Rank
Plants				
Golden Wave Tickseed	*Coreopsis intermedia*	C	G2G3S2S3	SC,C2
Barberry-leaved Hawthorn	*Crataegus berberifolia*	P	G1S1	SC,C2
Southern Lady's Slipper Orchid	*Cypripedium kentuckiense*	C	G2G3S1	SC,WL,C2
Neches River Rosemallow	*Hibiscus dasycalyx*	P	G1S1	SC,WL,C2
Inkberry	*Ilex glabra*	P	G5S1	NL
Thicket Bean	*Phaseolus polystachios*	P	G4S1	NL
Texas Trillium	*Trillium pusillum* var. *texanum*	P	G2G3QS2S3	SC,WL,C2
Communities				
Water Oak-Willow Oak Series	*Quercus nigra-Q.phellos* community	C	G4S3	NA
Baldcypress-Water Tupelo Series	*Taxodium distichum-Nyssa aquatica* community	C	G4S3	NA

KEY:

Occurrence Notations

C = confirmed record in project area
P = potential occurrence in project area

TABLE 1 (continued)
THE CADDO LAKE PROJECT
RARE PLANT AND ANIMAL SPECIES AND NATURAL COMMUNITIES

The Nature Conservancy Ranking System

The G 1 global rank indicates the highest level of concern for a species. At thr other end of the scale, G5 indicates that a species is abundant and secure over i t ' s total range - even if it is rare, declining, or extirpated in some areas. state ranks similarly reflect the species' rarity or abundance within a specific state. The global and state ranks can be combined to present the state status of a species in a global context. Thus, a G3Sl ran indicates moderate rarity worldwide and extreme rarity within a particular state.

Global Rank (denoted by G and a number, l-5 or H)

Cl = less than 6 occurrences known globally; critically imperiled, especially vu!nerable to extinction;
G2 = 6-20 occurrences known globally;imperiled and very vulnerable to extinction throughout its range;
G3 = 21-100 occurrences known globally;either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g., a single state or physiographic region)', or because of other factors making it vulnerable to extinction throughout its range;
G4 = more than 100 occurrences known, apparently secure globally, though it ray be quite rare in parts of its range, especially at the periphery;
G5 =Demonstrably secure globally,though it may be quite rare in parts of its range;
GH =Of historical occurrence throughout its range, i.e.,formerly part of the established biota, with expectation that it may be rediscovered.

State Rank (denoted by S and a number, 1-5 or H)

Sl =less than 6 occurrences known in Texas;critically imperiled in Texas; especially vulnerable to extirpation from the state;
S2 =6-20 known occurrences in Texas;imperiled in the state because of rarity; very vulnerable to extirpation from the state;

TABLE 1 (concluded)
THE CADDO LAKE PROJECT
RARE PLANT AND ANIMAL SPECIES AND NATURAL COMMUNITIES

S3 = 21-100 known Texas occurrences; either rare or uncommon in the state;
S4 = more than 100 occurrences in Texas; apparently secure in the state, though it may be quite rare in some areas of the state;
S5 = Demonstrably secure in Texas
SH = historical in Texas, perhaps having, not been verified in the past 20 years, but suspected to be extant.

A global or state rank followed by "Q" indicates that the taxonomic status of the plant is a matter of conjecture. A rank followed by "?" indicates that the rank is not certain. A "T" subrsnk following a global rank denotes subspacific taxa. Two G or S ranks together (G2G3; S1S2, etc.) indicate that the plant is borderline between the ranks.

Texas Natural Heritage Program (TNHP), Texas Organization for Endangered Species (TOES), State, and Federal Ranking Systems

SC = TNHP list, species of special concern.
WL = TOES watch list
T = TOES list, threatened species
E = TOES list, endangered species
ST = state list, threatened species
SE = state list, endangered species
FT = federal list, threatened species
FE = federal list, endangered species
FPT = proposed to be federally listed as threatened species.
FPE = proposed to be federally listed as endangered species
Cl = federal candidate category 1 species with enough information available to propose for listing as either endangered or threatened
c2 * federal candidate category 2 species under current review for possible listing as either endangered or threatened, but more information needed

A WATERFOWL TECHNICAL APPENDIX

for the

RED RIVER WATERWAY
SHREVEPORT TO DAINCERFIELD REACH
REEVALUATION STUDY

Prepared by

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U.S. Fish and Wildlife Service
Southeastern Region
Atlanta, Georgia
May 1993

United States Department of the Interior
FISH AND WILDLIFE SERVICE

900 Clay Street, Room 235
Vicksburg, Mississippi 39180

May 7, 1993

Colonel Stephenson W. Page
District Engineer
U.S. Army Corps of Engineers
2101 North Frontage Road
Vicksburg, Mississippi 39180-5191

Dear Colonel Page:

Enclosed is the Waterfowl Technical Appendix for the Red River Waterway Shreveport to Daingerfield Reach Reevaluation Study. The information contained in the appendix is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. et seq.), but does not constitute the final report of the Department of the Interior, Fish and Wildlife Service, as required by Section 2(b) of the Act.

We appreciate the opportunity to provide this technical appendix. The cooperation shown by your staff was vital to our efforts. Should you or your staff have questions please do not hesitate to call me.

Sincerely,

Charles A. McCabe
Acting Field Supervisor

cc:
Fish and Wildlife Sevice, Regional office, Atlanta, GA
Fish and Wildlife Sevice, Arlington, TX
Louisiana Department of Wildlife and Fisheries, Baton Rouge, LA
Texas Parks and Wildlife Department, Austin, TX

Red River Waterway Project
Shreveport,LA, to Daingerfield, TX, Reach
Reevaluation Study In-Progress Review

APPENDIX 5
WATERFOWL RESOURCES

EXECUTIVE SUMMARY

This summarizes the findings contained in the U.S. Fish and Wildlife Service's (Service) Waterfowl Technical Appendix associated with the Vicksburg District, U.S. Army Corps of Engineers (Corps) supplemental environmental report for the Shreveport to Daingerfield navigation channel. It is the Service's understanding that this Waterfowl Appendix is to become an integral part of the supplemental environmental report.

The major impacts of the four barge alternative navigation channel to wintering waterfowl would occur primarily in the Cypress Basin in east Texas and northwest Louisiana. The bulk of the Cypress Bayou Basin occurs within the Pineywoods ecological region of east Texas with a smaller portion extending into Louisiana. Therefore, this appendix will deal with the history and development of east Texas wetlands and the effects of these losses to wintering waterfowl.

Because of the loss of migratory waterfowl habitat, continental breeding populations are alarmingly below long term averages. Wintering populations and harvests in the Pineywoods ecological region appear to be following this same trend. Since loss and degradation of habitat have been identified as the major waterfowl management problem in North America, quantifying the impacts of the Shreveport to Daingerfield navigation channel in terms of alteration to wintering waterfowl carrying capacity and foraging habitat in the project area, is the primary purpose of this appendix.

Using with and without hydrology and land use data supplied by the Corps, the impact methodology used was based on food as an index of wintering waterfowl carrying capacity expressed in terms of numbers of duck-days. Impacts in terms of increases and decreases of average seasonal acres flooded, during the 120 day wintering period from November 1 to February 28, were also identified.

If completed, the four barge channel alignment would substantially reduce the amount of migratory waterfowl foraging habitat on private and public lands. Additionally, wintering migratory waterfowl foraging carrying capacity in the project area would be reduced annually by approximately 125,475 duck-days. It is important to note that the project area contains some of the most extensive bottomland hardwoods left in east Texas which have significant waterfowl resource values. Within the context of the Service's Mitigation Policy, the loss of habitat supporting the wintering migratory waterfowl are designated Resource Category 2, with a mitigation goal of no net loss of in-kind habitat values.

Additionally, this appendix contains measures available to mitigate for the loss of duck-days. Conceptual in nature, the measures rely primarily on the acquisition and intense management of land for wintering waterfowl.

The Service appreciates the opportunity to provide this technical appendix. Questions or clarification relating to content should be directed to our Ecological Services Field Office, Vicksburg, Mississippi.

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JNTRODUCTION

This Waterfowl Technical Appendix (appendix) addresses activities pertaining to U.S. Army Corps of Engineers (Corps) Vicksburg District's Reevaluation Study for the Shreveport, Louisiana to Daingerfield, Texas Reach of the Red River Navigation Project. The purpose of this appendix is threefold. First, to identify the relative importance of the general project area to eastern Texas and western Louisiana in terms of historic trends of wintering waterfowl, primarily mallards (Anas platyrhynchos). Secondly, to document the baseline wintering waterfowl carrying capacity in the project area, and thirdly, to document project induced changes and impacts to those baseline conditions using food as an index expressed in terms of duck-days.

While this appendix is limited to an analysis of project impacts to wintering waterfowl, additional technical appendices prepared inhouse by the Vicksburg District or the Waterways Experiment Station will evaluate project impacts to aquatic resources, water quality, ground water, and wetlands. The Arlington, Texas Ecological Service field office will prepare a terrestrial appendix. The information contained in the appendix does not constitute the final report of the Department of Interior, U.S. Fish and Wildlife Service, as required by Section 2(b) of the Act.

STUDY AREA

The proposed Shreveport to Daingerfield segment of the Red River Navigation project is located in the Cypress Bayou Basin in northeast Texas and the Caddo Lake and Twelvemile Bayou drainage in northwest Louisiana. It is bounded on the north by the Sulphur River Basin, on the west and south by the Sabine River Basin, and the Red River to the east (Figure 1). The watershed lies within Franklin, Wood, Hopkins, Titus, Camp, Morris, Cass, Upshur, Gregg, Marion, and Harrison Counties in Texas, and Caddo Parish in Louisiana.

Major streams of the Cypress Bayou Basin include Big Cypress, Little Cypress, Black Cypress, and Frazier Creeks. Major existing reservoirs are located only on the Big Cypress drainage and include Lakes Cypress Springs, Caddo Lake, Monticello, Bob Sandlin, and Lake O'the Pines. Several smaller reservoirs, such as Welsh, Ellison Creek, Barnes Creek, and Johnson Creek, occur on tributaries to Big Cypress Bayou. The entire basin, including Caddo Lake and Twelvemile Bayou,has a length of approximately 100 miles, a maximum width of 48 miles, and drains approximately 3,000 square miles.

The bulk of the Cypress Bayou Basin occurs within the Pineywoods ecological region of Texas and Louisiana, with only the extreme western portion of the basin occurring in the Post Oak Savannah ecological region (Gould 1975). The Pineywoods are dominated by pine-hardwood forest; however, changes in land use have dissected the once contiguous forest into a patchwork of different land uses. Currently, the principal land uses include hay production, cattle grazing, and pine timber production (Hayes 1987). Oil and gas exploration and production have also contributed to the reduction of forested stands.

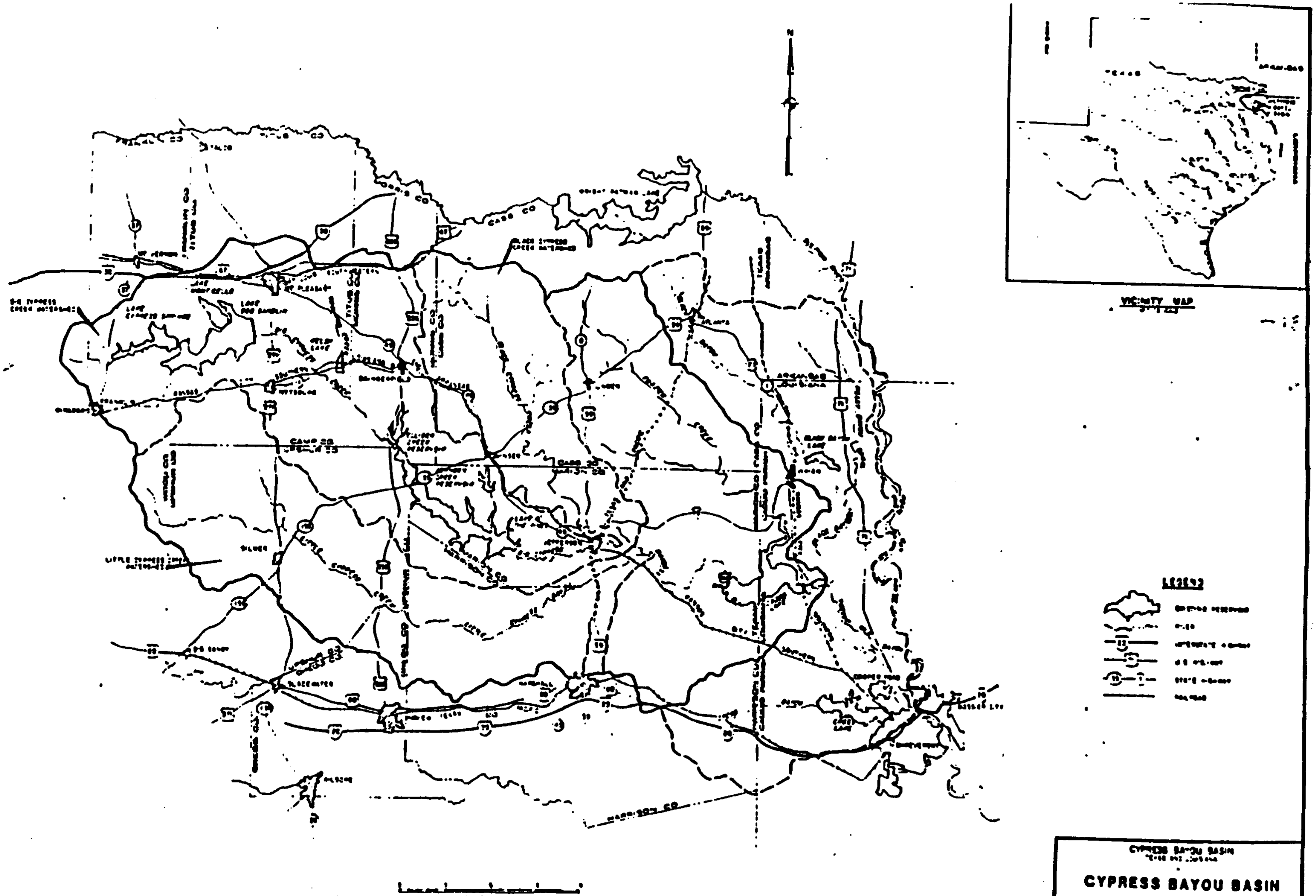


Figure 1. Cypress Bayou Basin, Texas and Louisiana.

PROJECT DESCRIPTION

The Shreveport to Daingerfield Evaluation Study was initiated in fiscal year 1989 at the direction of Congress. It is a segment of the Red River Navigation Project which was authorized in accordance with House Document No. 304, dated May 2, 1968. The authorized project provided for 76 miles of navigation channel, approximately nine feet deep and 200 feet wide, with locks located at Caddo Lake and Lake O' the Pines, and in the vicinity of Jefferson, Texas. At least 18 stream bendways, containing 14 miles of natural stream channel, would be cut off by the navigation channel.

The Corps stated in their December 1992, In-Progress Review Report for Reevaluation Study that the Daingerfield reach was neither economically nor environmentally feasible (U.S. Army, Corps of Engineers 1992). The report further stated that extension of navigation would have significant adverse effects on aquatic and terrestrial habitat in the project area. Therefore, the Corps recommended that the overall study be terminated and provided a schedule and related cost estimates for completion of various component studies.

Alternatives for the Shreveport to Daingerfield Navigation Project

The original Shreveport to Daingerfield Reevaluation Study outlined four navigation channel alternatives: two and four barge channels following the existing water course, and an alternative two and four barge channel through Goose Prairie in Caddo Lake. Due to time constraints associated with termination of the reevaluation study, the Corps and the Service will be looking at only the four barge alternative plan for authorized alignment, for the various component studies (including this waterfowl appendix) for the supplemental environmental report.

A HISTORICAL PERSPECTIVE OF WETLANDS AND UATERFo~L IN EAST TEXAS AND NORTHWEST LOUISIANA

In order to understand the natural resource issues facing wintering waterfowl in the 1990's, it is important to understand the past attitudes and events that resulted in today's conditions. Many of those past attitudes and events continue to persist throughout east Texas and northwest Louisiana, and strongly influence wetlands and waterfowl management.

Wetlands

In 1980 a very extensive, detailed, and accurate statewide inventory of vegetation was completed by the Wildlife Division of the Texas Parks and Wildlife Department using data from the Landsat satellite system. Classification accuracy in discriminating bottomland hardwoods and similar riparian vegetation generally was quite high with error rates usually below 10 percent (McMahan *et al.* 1984).

The amount of bottomland hardwood and associated riparian vegetation occurring prior to the settlement of Texas is estimated at 16 million acres (Figure 2). This estimate is based on acreage of occurring geologic floodplain in Texas and assumes that all or most of these flood plains were originally forested (Kfer et al. 1977). Remaining bottomland vegetation (excluding swamps) inventoried by Landsat was 5,973,000 acres in 1980, indicating a 63 percent loss of the original bottomland component. Most of these bottomland hardwoods occur in east Texas. The floodplains of six major rivers, including the Trinity, Neches, Sabine, Sulphur, Angelina, and Cypress Bayou, have l-2 million acres and an additional three million acres are contained in their tributaries, yielding a total hardwood acreage of 4,231,OOO acres in east Texas (McMahan et al. 1984). The majority of the remaining bottomland hardwoods are being threatened by various water resource projects, especially reservoirs. The Texas Water Plan identifies 44 reservoirs proposed for construction by the year 2030 to satisfy projected water needs (Texas Department of Water Resources 1984). The majority of these are located in the eastern portion of the state. Over 1.5 million acres of natural vegetation comprising over 600,000 acres of bottomland hardwoods have been lost from reservoirs already constructed, with the prospect of additional inundation of almost 900,000 acres of mixed cover types from reservoirs listed in the water plan (Moulton 1990). In addition to these impacts, other reservoirs have been proposed by local water entities that have not been included within the water plan. As these projects are constructed the total future loss of natural vegetation may easily exceed one million acres (Frye et al. 1987).

Losses from <u>indirect</u> impacts downstream of reservoirs include increased clearing for agriculture, increased residential and commercial development, increased market potential of timber due to access, and long term biological modification of riparian ecosystems. Notwithstanding reservoir development, additional losses are expected to occur to riverine systems from ongoing timber harvest operations which are being sustained by a demand for hardwood products and a continuing desire from owners to market timber within floodplain areas that have been previously unattractive.

By the mid 1980's, concern for environmentally sensitive land, particularly wetlands, and concern for an agricultural economy dominated by surplus began to find common ground. The 1985 Farm Bill established for the first time a direct link between federal agricultural policies and wetland policies with provisions that deny federal subsidies to anyone bringing more wetlands into agricultural production. At nearly the same time, the longstanding concern of Congress for migratory waterfowl was renewed in the broader context of conserving the nation's wetlands as the Congress passed the Emergency Wetlands Resources Act of 1986, "...an act to promote the conservation of migratory waterfowl and to prevent the serious loss of wetlands." Likewise, Canada and the United States renewed their international commitment to waterfowl conservation with the signing of the North American Waterfowl Management Plan (NAWMP) in 1986. And again in 1986, with the passage of the Water Resources Development Act, Congress provided a clear mandate to the Corps to conserve fish and wildlife. The Agricultural Credit Act of 1987 provided expanded authority to conserve

ORIGINAL = 100,000 ACRES

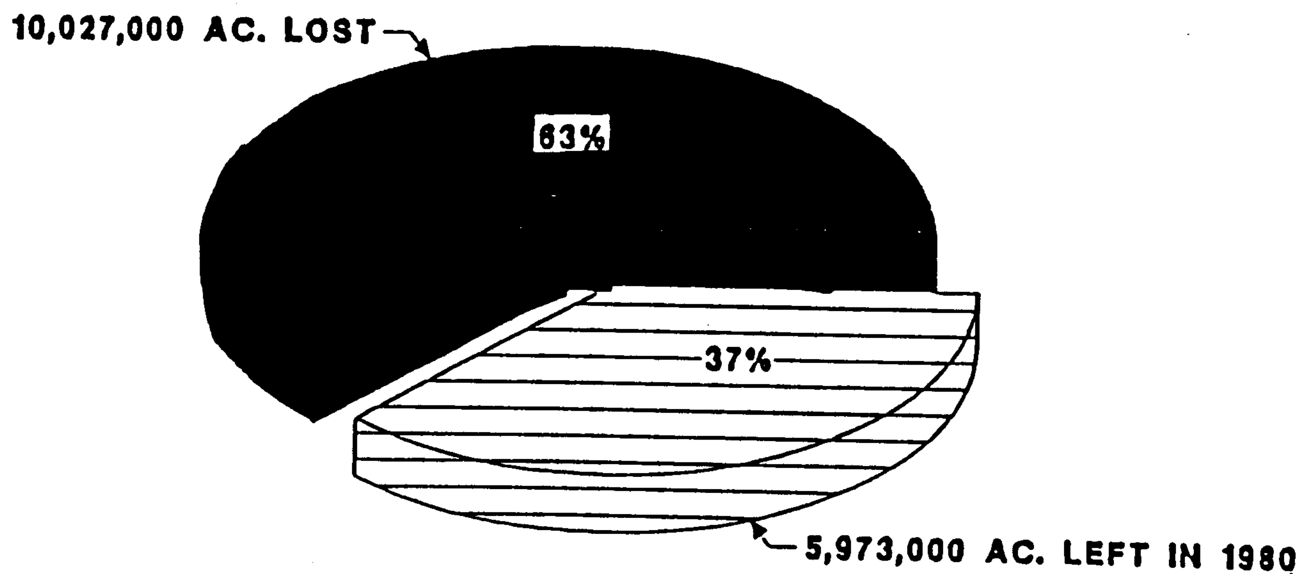


Figure 2, Loss of forested wetlands in Texas from pre-settlement to 1980
Source: Moulton 1990.

wetlands in the disposal of federal inventory lands with regulations specifically referencing the NAWMP. For some of the wetlands cleared during the expansion years, the circle became complete in 1989 when federal assistance was offered to reestablish bottomland hardwoods on "farmed wetlands" and "scoured floodplain" enrolled in the U.S. Department of Agriculture's (USDA) Conservation Reserve Program. Former President Bush established a commitment to wetland conservation through a policy of no net loss of wetlands. Finally, the 1990 Farm Bill expanded provision of the 1985 Farm Bill providing for the withdrawal of an additional 1,000,000 acres of agricultural wetlands by 1995 to reduce commodities already in surplus.

Waterfowl

Continental waterfowl populations were also experiencing long term change during the 1960's, 70's, and 80's. Populations were at high levels during the mid 1950's and then declined in the early 1960's due to drought conditions in the prairie pothole nesting regions of the U.S. and Canada. Populations increased during the late 1960's and early 1970's and remained

at fairly high levels throughout the 1970's. Severe drought in some of the nesting areas affected productivity during the early 1980's, and total duck breeding populations reached record lows in the late 1980's. Many species, including mallards, are well below peak numbers recorded in the 1950's and remain alarmingly below the long term average (Table 1).

TABLE 1
BREEDING DUCK POPULATION ESTIMATES
(in thousands)[1]

Years	Mallard	Gadwall	American Wigeon	Green-winged Teal	Northern Shoveler	Northern Pintail
1955-60	9,386	651	3,195	1,584	1,556	8,543
1961-65	6,062	928	2,310	1,228	1,368	3,514
1966-70	7,805	1,641	2,702	1,652	2,105	5,177
1971-75	8,284	1,544	2,973	1,873	2,026	5,968
1976-80	7,800	1,457	3,012	1,851	1,910	4,891
1981-85	5,915	1,483	2,616	1,612	1,934	3,240
1986-90	5,932	1,443	2,002	1,860	1,789	2,334
1991	5,353	1,573	2,328	1,601	1,663	1,798
Mean	7,299	1,296	2,691	1,662	1,801	4,596

[1] Adapted from U.S.Fish and Wildlife Service 1992.

The plight of waterfowl in eastern Texas and northwestern Louisiana mirrors the historic loss of wetlands. The net effect of wetland conversion and drainage has been that natural habitat is no longer sufficient to meet the needs of wintering waterfowl and other migratory birds. Clearing for grazing, timber harvesting, agriculture, and reservoir projects have all contributed to the decline of bottomland hardwoods in the region.

Bottomland hardwoods are a major vegetation cover type within the Cypress Bayou-Twelvemile Bayou Basins, occupying more than 320,000 acres of the combined basins (U.S. Fish and Wildlife Service 1991). Harrison Bayou and some areas within the Longhorn Ammunition Plant contain old growth and virgin hardwoods, but their area1 extent has not been documented. These areas are extremely important to waterfowl for cover, feeding, and resting. Many bottomland areas in this region have been placed in a priority one or two land protection plan category based primarily on their benefit to waterfowl (U.S. Fish and Wildlife Service 1985). Within the context of the Service Mitigation Policy, the loss of habitat supporting waterfowl foraging habitat/duck-days are designated Resource Category 1 with a mitigation goal of no loss of existing in-kind habitat and foraging duck-days.

Forested wetlands are highly integrated,open systems with continuous inflow and outflow of energy, sediments, nutrients, and species between aquatic and terrestrial environments (Moulton 1990). Forested wetlands may be separated into six recognizable zones based on the extent of soil saturation or inundation, soil type, shade tolerance, and competition (Figures 3 and 4). The ecological values of hardwood bottomlands to waterfowl and other species cannot be overemphasized (Table 2).

While the annual breeding bird surveys are the most reliable estimates of waterfowl populations, population estimates are also available from extensive surveys of wintering ducks as well as from waterfowl harvest data. Since these latter two surveys are broken down into states and counties, they are more easily identifiable with east Texas, and to some degree, Cypress Bayou Basin. Although numerous surveys have been conducted for wintering ducks in coastal Louisiana and the Mississippi Alluvial Valley, no waterfowl surveys have been conducted for wintering waterfowl in northwestern Louisiana. However, this area is an important migratory corridor for waterfowl (Enfinger 1993). Several lakes in and around Cypress Bayou are used by wintering waterfowl for resting and feeding. They include Caddo Lake, Lake 0' The Pines, Soda Lake (Soda Lake WMA contains 1,300 acres managed as a moist soil unit for waterfowl), Cross Lake, Wallace Lake, Cypress Lake, and Black Bayou Lake (Butcher 1993).

Conducted in January each year by the Service and the states, the midwinter survey is an attempt to count the total number of ducks of each species. The resulting population estimates are not considered of sufficient reliability to measure trends in abundance of most duck species because of the large area which must be surveyed and the difficulty of counting birds, especially in wooded habitats, and the lack of a statistical sampling frame.

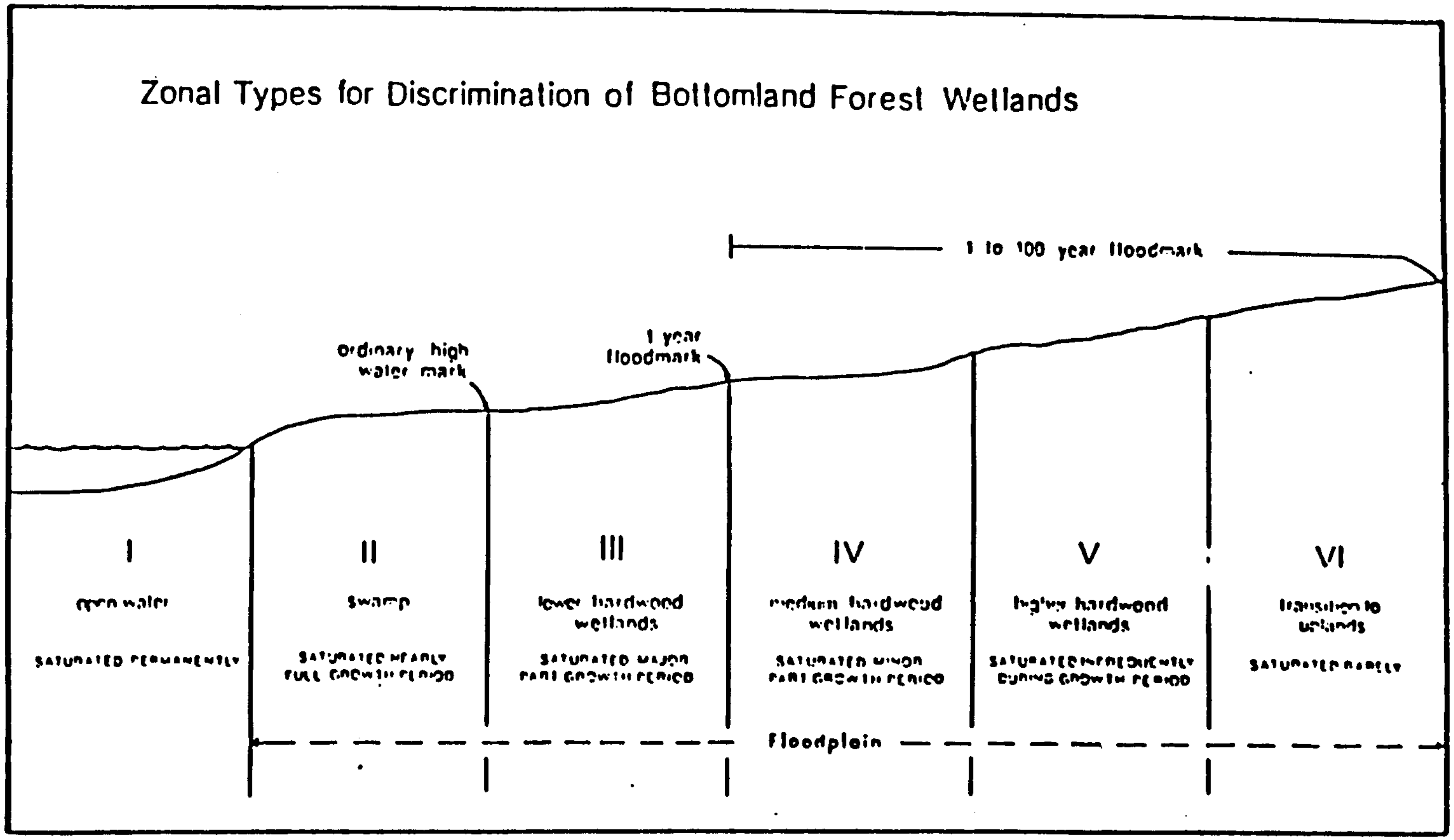


Fig. 3. Classification of southeastern hardwood bottomland forest.
Source: Larson et al. 1981.

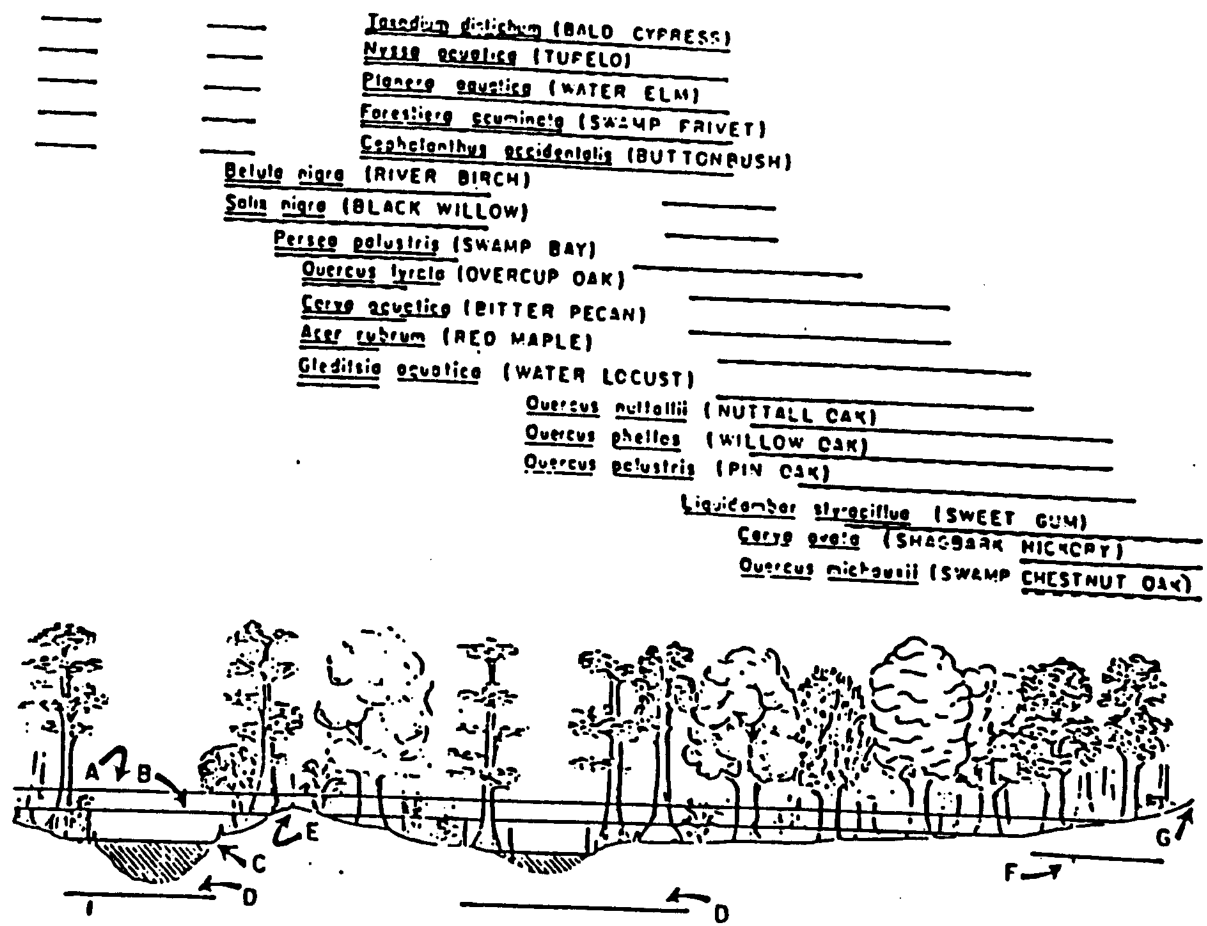


Fig.4. Cross section of a Mississippi—Delta HBL Wetland.
Source: Fredrickson 1979.

Table 2. Ecological values of hardwood bottomlands.

VALUE TYPE	HARDWOOD BOTTOMLAND TYPE			
	II	III	IV	V
Nutrient Output	High	High	High	Medium
Primary Productivity	Medium	Medium	High	Medium
Water Quality Improvement	High	High	High	Medium
Physical Buffer Against Erosion	High	High	Medium	†
Flood Storage	†	Medium	High	Medium
Waterfowl	Medium	High	High	†
Zooplankton (food base)	High	High	Medium	†
Aquatic Animals	High	High	Medium	†
Endangered Species	†	†	Medium	Medium
Shorebirds and Wading Birds	High	High	†	†
Non-game Birds	†	Medium	Medium	Medium
Fish (Adult)	High	High	High	Medium
Fish (Young)	Medium	High	High	Medium
Terrestrial Wildlife	†	Medium	Medium	High

Source: Clark and Benforado 1981.

The combined Pineywoods and North Central regions account for approximately nine percent **of** ducks wintering in Texas (Figure 5). This is misleading because ducks are surveyed only on the large reservoirs where they are visible from aircraft and true numbers wintering in the Pineywoods and North Central regions are not accurately documented (Moulton 1990). These surveys always count fewer ducks than are actually present, but the amount of undercount is unknown and is likely highly variable from year to year. Nevertheless, these surveys do provide useful general information on waterfowl population levels (Tables 3 and 4).

Waterfowl harvests have fluctuated since records have been kept, being lowest during early 1960's when populations, potential hunters, and days afield were low. In most years, harvests have tracked the fluctuation of these factors, especially populations. In recent years, nationwide harvests of the heavily hunted mallard and of total ducks remained relatively constant, while hunter numbers declined and hunter success increased. Thus, it appears that in recent years fewer hunters have been increasingly successful at harvesting ducks (Table 5 and Figure 6). Although more ducks are harvested in the north central and coastal areas of Texas, the Pineywoods ecological region is still important to hunter success (Figure 7) and is one of the prime areas for mallards and wood ducks.

WINTERING WATERFOWL BIOLOGICAL CHARACTERISTICS

Habitat Reauirements

The loss and degradation of habitat have been identified as the major waterfowl management problem in North America (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1986). Habitat requirements for wintering waterfowl can be broken down into three components: availability, utilization, and suitability in meeting social behavioral requirements.

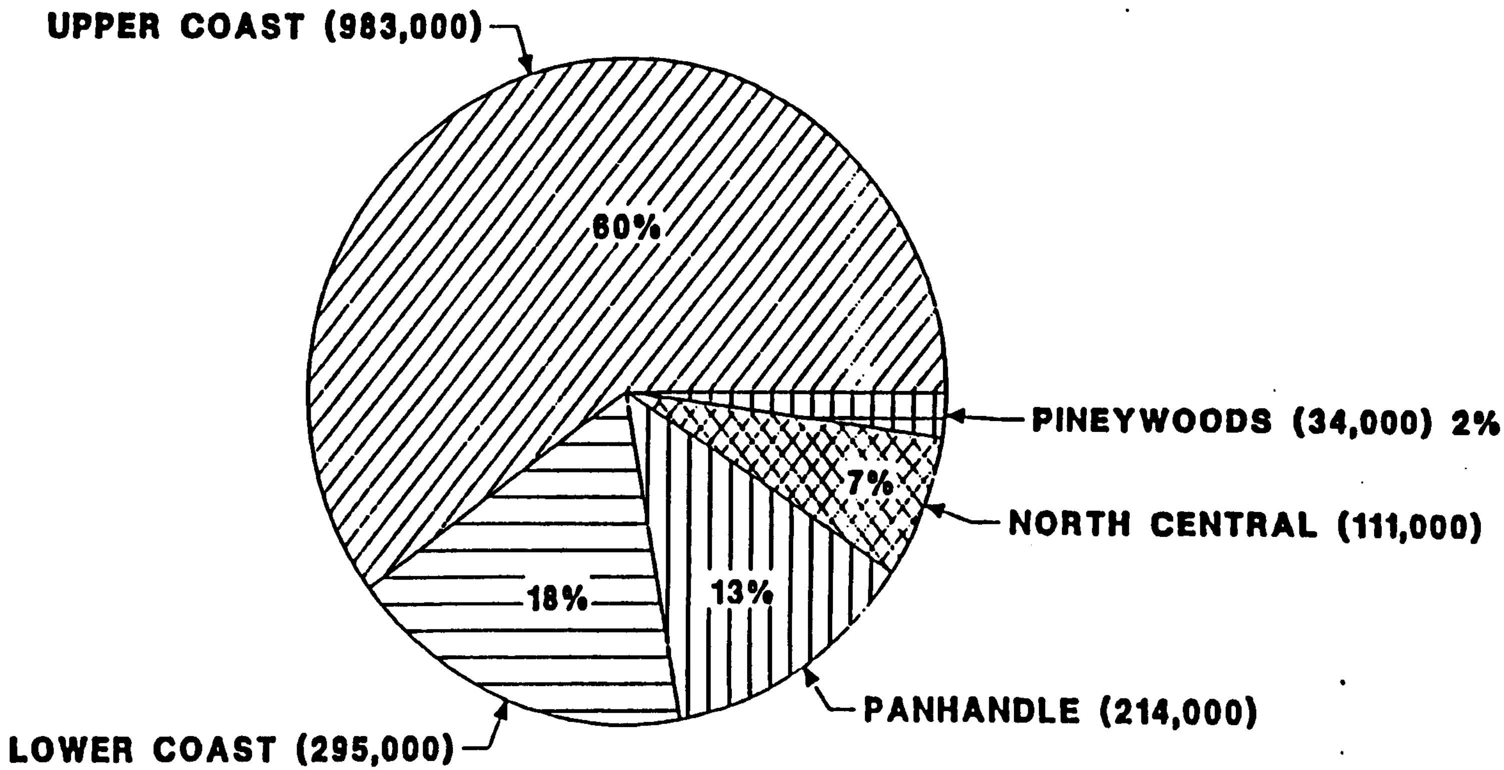
Utilization

In recent years, research has focused on the relative waterfowl use, and associated food availability, in natural and agricultural foraging habitats. Not surprisingly, use differs greatly, not only between natural or native plant species, but also between the various small grain agricultural crops.

Waterfowl are mobile and opportunistic, and their feeding habits have changed over time, presumedly in response to the large scale conversion of native wooded wetlands to pastures and small grain agricultural lands. Variable among locations and among years within locations, the principal foods of mallards generally include agricultural grains; seeds and tubers of native soil plants; acorns; and invertebrates such as isopods, snails, and fingernail clams (Reinecke et al. 1987). Heitmeyer (1985) and Combs (1987) found that pin oak (*Quercus palustris*) and cherrybark oak (*Quercus*

AVERAGE ESTIMATED NUMBERS OF WINTERING DUCKS

TEXAS (1983-85)



STATEWIDE = 1,637,000

TABLE 3
MIDWINTER WATERFOWL SURVEY FOR NORTHEAST TEXAS[1]
(in thousands)

Years	Mallard	Gadwall	American Wigeon	Green-winged Teal	Northern Shoveler	Northern Pintail	Total
1958-62	136,896	5,384	5,374	5,457	1,777	10,889	165,777
1963-67	273,534	45,592	184,265	24,722	9,400	62,881	600,394
1968-72	400,450	21,923	43,087	35,060	2,845	16,777	520,142
1973-77	236,358	30,143	8,783	10,525	2,131	16,373	304,313
1978-82	299,100	78,150	16,950	2,000	1,000	2,900	400,100
1983-87	28,400	32,600	7,400	3,000	100	8,800	80,300
1988-92	47,500	20,600	11,700	13,600	100	46,557	140,057

[1] Adapted from U.S. Fish and Wildlife Service 1992.

TABLE 4
MIDWINTER WATERFOWL SURVEY FOR LOUISIANA[1]
(in thousands)

Years	Mallard	Gadwall	American Wigeon	Green-winged Teal	Northern Shoveler	Northern Pintail	Total
1971-75	390	757	248	733	192	455	2,775
1976-80	837	812	206	692	142	488	3,177
1981-85	423	606	133	450	130	687	2,429
1986-90	528	678	150	436	153	390	2,335
1991	397	607	177	662	207	275	2,325
Mean	537	708	184	582	157	494	2,662

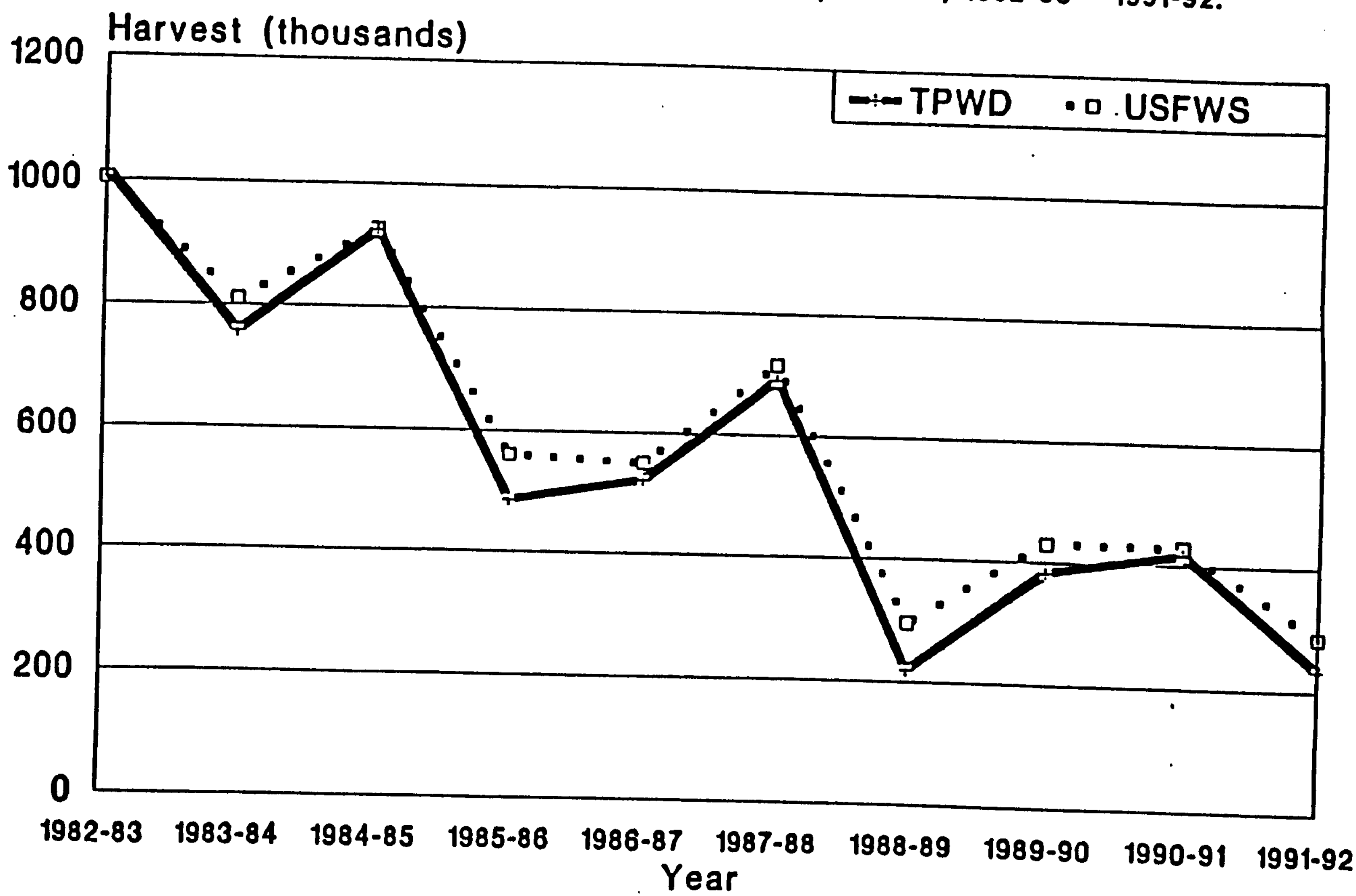
[1] Gamble 1989, 1990, and 1991. Includes both coastal plain and marsh habitats and are thus considerably higher than would be the case for those ducks wintering only in northwestern Louisiana.

TABLE 5. WATERFOWL HARVEST SURVEY 1982 - 1992[1]

	WATERFOWL HUNTING AREA--PINEYWOODS GEOGRAPHICAL UNIT (TEXAS)										
DUCKS	1982/83	1983/84	1984/85	1985/86	1986/87	1987/88	1988/89	1989/90	1990/91	1991/92	AVERAGE
Mallard	13,151	12,462	10,530	6,521	8,198	9,259	5,156	9,805	10,187	7,240	9,250.90
Pintail	2,403	2,650	1,430	826	535	793	488	639	453	606	1,082.30
Am. wigeon	2,054	1,197	1,088	219	542	930	86	4,452	4,753	1,901	1,722.20
Wood duck	16,048	21,179	13,843	11,344	9,483	14,064	6,514	9,253	14,678	8,935	12,534.10
G.W. teal	8,212	6,676	6,933	2,786	3,802	10,244	4,384	4,761	4,582	1,975	5,435.50
B.W. teal	6,450	2,185	2,857	1,243	2,426	2,420	162	557	1,092	132	1,952.40
Shoveler	862	1,161	745	606	1,578	777	238	607	1,321	808	870.30
Scaup	5,223	4,627	7,681	3,000	2,575	1,105	1,037	1,547	3,669	2,503	3,296.70
Canvasback	513	889	1,117	250	103	---	---	---	---	---	287.20
Redhead	166	291	683	362	---	114	227	---	164	101	210.80
Mottled duck	567	116	293	95	145	97	274	338	1,076	210	321.10
Gadwall	4,263	7,335	6,030	4,119	5,395	2,754	1,445	3,087	5,799	3,594	4,382.10
Whist. duck	---	---	---	122	125	287	---	122	449	107	121.20
Other ducks	3,243	2,821	3,645	1,146	1,931	852	1,395	1,297	1,479	779	1,858.80
TOTAL	63,156	63,588	56,877	32,638	36,838	43,695	21,406	36,465	49,701	28,891	43,325.50

[1]Texas waterfowl harvest survey 1982-92.

Figure 6. Comparison of duck harvest estimates by the U.S. Fish and Wildlife Service and Texas Parks and Wildlife Department, 1982-83 - 1991-92.



* 1991-92 estimates are preliminary

Source: Frentress 1992.

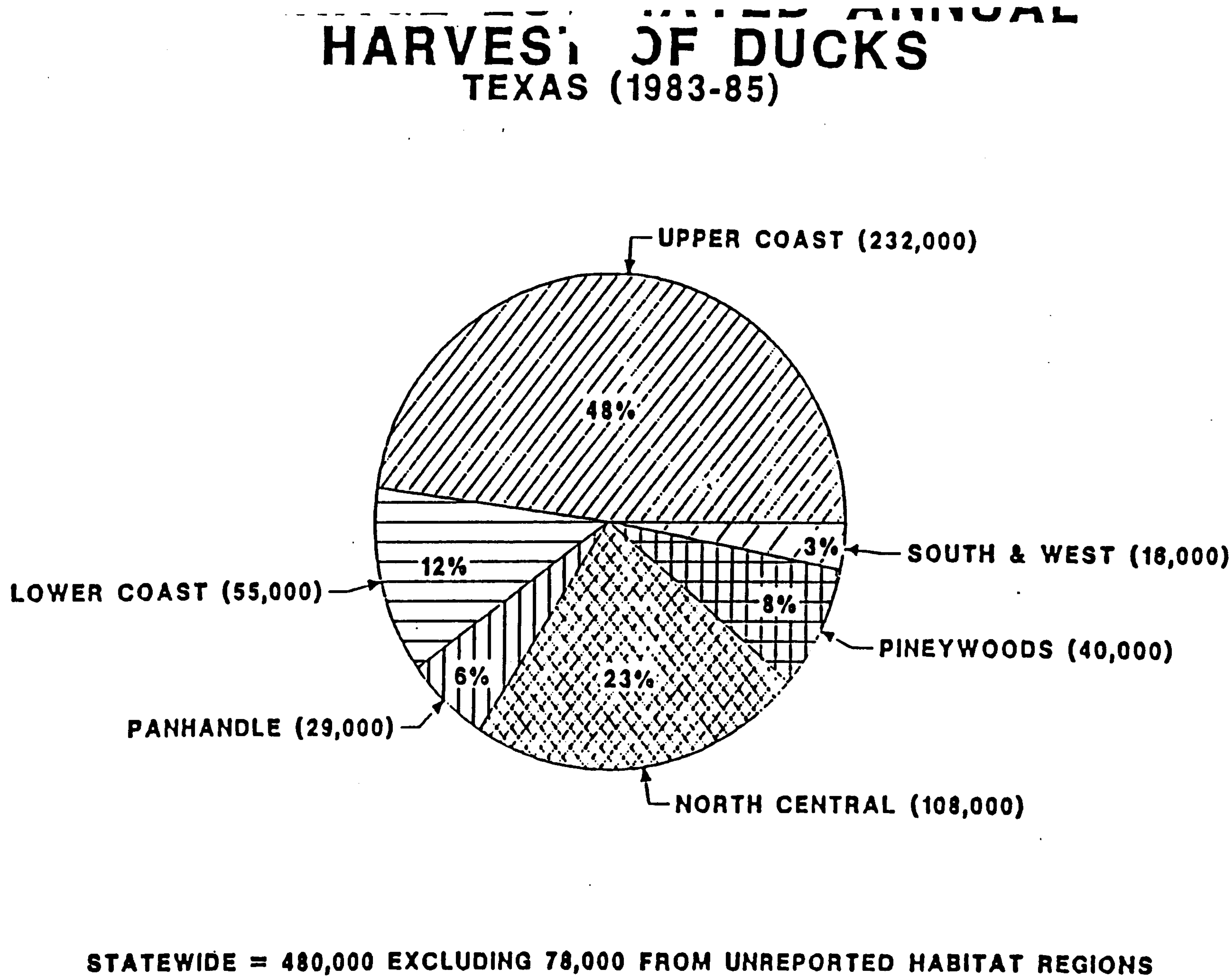


Figure 7. Average estimated annual harvest of ducks Texas (1983-85) by habitat region.
Source: Moulton 1990.

falcata var. *pagodacfolia*) acorns dominate the mallard diet during years of good mast production and favorable water conditions in southeastern Missouri.

Mallards concentrate on recently flooded openings with shallow depths in bottomland forests in the early fall. Shortly after arrival, mallards complete prealternate (breeding plumage) molt and consume aquatic insects and moist soil seeds. Following molt, mallards begin courtship and by early January 90 percent of the birds are paired (Bellrose 1980). During pairing mallards forage intensively in flooded forests or agricultural fields where they consume acorns and cereal grains. After pairing, mallards readily use shallowly flooded forests and continue to consume acorns, but increase consumption of macroinvertebrates (Table 6, Fredrickson and Batema 1992).

Wood ducks (*Aix sponse) use* overcup oak, cypress/tupelo forest types and scrub/shrub habitats during fall courtship and pairing (Bellrose 1980). After pairing, wintering habitat includes the deeper areas of lowland hardwoods, cypress/tupelo, overcup oak, and scrub/shrub habitats.

Wright (1961) and Delnicki and Reinecke (1986) demonstrated the importance to waterfowl of large areas of flooded rice and soybean fields. Seeds and tubers of grasses, sedges, and other moist soil plants are also important components of the diet (Wright 1961, Wills 1970, Heitmeyer 1985, Delnicki and Reinecke 1986, Combs 1987). Invertebrates generally provide less than 10 percent of the diet *in* agricultural (Delnicki and Reinecke 1986) and moist soil (McKenzie 1987) habitats, but may be more important in forested wetlands (Heitmeyer 1985). The nutrition of wintering waterfowl is not well understood. It is; however, increasingly clear that nutrition affects dietary energy and protein intake, and that meeting these dietary requirements is positively related to winters with normal or above normal rainfall. Studies conducted in Mississippi during the wet winter of 1982-83 show increased mallard body weights while the dry winter of 1980-1981 show decreased mallard body weights (Delnicke and Reinecke 1986). Similar results in Missouri indicated that mallard body weights increased when water conditions and mast production were favorable, or when rainfall was sufficient to flood low lying cropland (Heitmeyer 1985, Combs 1987).

Social Behavior

During winter, courtship and pair formation dominate the social behavior of dabbling ducks. While in most of the Cypress Bayou basin pasture and agricultural lands have replaced forested wetlands as the primary foraging habitat, the forested wetlands and normally associated shrub swamps, beaver ponds, and riparian habitat are used as resting or roosting areas and provide isolation from human disturbance, protection from predators, and a location for courtship and other social activities. Whereas much of the foraging and nutritional requirements can be met by flooded agricultural lands, a variety or complex of habitats is needed to satisfy the total biological requirements of wintering mallards, because members of the population may differ in their habitat needs at any particular time (Reinecke et al. 1987). Examples include the likelihood of juvenile or

Table 6. Types, relative abundance and relative biomass of foods associated with lowland hardwood habitats.[1]

	Cypress/tupelo	Oak dominated live forests	Dead tree	Scrub/shrub	Slough/ open water	Moist-soil
Plant foods						
Energy						
Acorns		+++[a]				
Samaras		+++				
Buttonbush			+	++	+	
Watershield			+	+	+++	
Millet						+++
Sticktights			+	+		+++
Protein						
Samaras		+++				
Sticktights			+	+		+++
Annimal Foods						
Protein						
Annelids						
Freshwater worms	+	+++	+	+	+	+
Crustacea						
Sowbugs	+	+++	+	+		+
Sideswimmers	+	+++	+	+		+
Insecta						
Bugs	+	+	+	+	+	+++
Beetles	+	+	+	+	+	+++
Flies	+	+	+	+	+	+++
Gastropoda						
Pond snails	+		+	+	+	+++
Orb snails	+	+	+	+	+	+++
Bivalvia						
Fingernail clams	+					

[a] **Relative abundance: +++ large number and biomass, ++ moderate number and biomass, + small number and biomass.**

[1] **Greentree Reservoir Management Handbook 1992.**

unpaired mallards feeding in agricultural lands and adults and pairs seeking the isolation of shrub swamps to avoid harassment from courting parties (Heitmeyer 1985).

IMPACT ASSESSMENT METHODOLOGY

This section presents the basic methodology for waterfowl impact assessment of the Shreveport to Daingerfield segment of the Red River Waterway, Navigation project using food as an index of carrying capacity. Using food as an index of carrying capacity is an acknowledgement that available food resources are limiting in terms of the number and distribution of wintering waterfowl within the Cypress Bayou basin. Additional detail concerning data requirements and calculation methods are contained in the Service's lower Mississippi Valley Joint Venture Project (LMVJVP) Monitoring and Evaluation Committee reports (Reinecke 1989).

In this section, the term wintering waterfowl includes primarily puddle ducks consisting of the mallard, northern pintail (*Anas acuta),* gadwall (*Anas strepera*), American wigeon (*Anas americana),* green-winged teal (*Anas crecca*). and northern shoveler (*Anas clypeata*). Although present, wood ducks,due to the specific requirements of the resident population, are included in a separate terrestrial habitat evaluation appendix being prepared as part of the Corps Supplemental Environmental Report.

Data Requirements

To determine carrying capacity in terms of numbers of duck-days, data requirements include land use, hydrology, and available food during the 120 day (November 1 to February 28) waterfowl wintering period. The data must be specific to those habitats and food resources that are available and can be used by foraging waterfowl.

For a determination of baseline and future carrying capacities, land use must be broken down into those available foraging habitats having food value to wintering waterfowl. As part of the supplemental environmental report, the Corps prepared a Geographical Information System (GIS) data base tailored to identify the acres of available foraging habitats under baseline conditions and future conditions with the four barge alternative completed. The data were broken down into acreage of cypress/tupelo, bottomland hardwood forested wetlands, and other (includes pasture, cropland, open water, etc.). Although the cypress/tupelo and "other" categories are included to account for the total seasonally flooded acreage, they have little or no food value to wintering waterfowl.

Since foraging habitat, regardless of food value, is only of use to wintering waterfowl if available, monthly and seasonal hydrological data were also necessary. The Corps provided daily, monthly, and wintering seasonal acres flooded for a 24-29 year period (depending on the reach) of record. The land use data provided for the study area were specific to those acres inundated and represent only potential available foraging habitat.

Using data previously developed by the LMVJVP Monitoring and Evaluation Committee, the amount of food available on a unit area was determined. Small grain crop residues, moist soil native weed seeds, acorns, and invertebrates in forest stands with more than 25 percent red oaks represent the available vaterfowl food.

Calculation Methods

Table 7 presents standard land use categories, available food, average available energy, average daily energy requirements, and average duck-day use per acre for the Cypress Bayou area. An example calculation of duck use days on one acre of inundated bottomland hardwood composed of 25-34 percent red oaks in any of the hydrological reaches in the project area would be:

27 kilograms/hectare (kg/ha) (bottomland hardwood) plus 22.5 kg/ha (weed seeds) plus 13.7 kg/ha (invertebrates) minus 50 kg/ha (food abandoned to decreased foraging efficiency) - 13.2 kg/ha of available food.

13.2 kg/ha (available food) times 3,500 kilocalories (kcal)/kg (energy available from food - 46,200 kcal/ha of available energy.

46,200 kcal/ha (available energy) divided by 292 kcal/duck day (energy required to support one duck for one day) - 158.2 duck days/ha.

158.2 duck-days/ha times 0.4047 - 64 duck-days/acre.

Caution is necessary in using the values found in Table 7. First, the data in the table are averages for the Cypress Bayou area and do not reflect values on lands specifically dedicated to production of food for wintering waterfowl. Lastly, bottomland hardwood forested wetlands have high potentials in terms of providing food. The value of flooded forested wetlands to wintering waterfowl is significant because these wetlands are essential in providing habitat to meet the behavioral requirements of waterfowl. Development of areas simply to accommodate large numbers of duck-days based solely on food needs should be undertaken with caution. The historic distribution of wintering waterfowl or the other biological needs of waterfowl, which are provided largely by forested wetlands, should also be considered.

PROJECT IMPACTS

This section defines the impacts of the Shreveport to Daingerfield project through a comparison of baseline conditions with those that would exist upon project completion. The Corps has made the determination that baseline (existing) conditions are synonymous with the future without project conditions as they pertain to potential foraging habitat for wintering waterfowl. This determination assumes that existing institutional requirements with regard to development in wetlands are sufficient to ensure continuation of baseline conditions.

TABLE 7. LAND USE, AVAILABLE FOOD, AVAILABLE ENERGY, DAILY ENERGY REQUIREMENTS, AND DUCK DAY-USE PER ACRE

	Available Food[1]						
Land Use	Crop Residue[2]	Red Oak Acorns	Weed Seeds[3]	Inverte-brates[4]	Average Available Energy[5]	Average Daily Energy Requirements[6]	Annual Average Duck-Days/Acre
Moist/Fallow[7]	--	--	364	--	2,500	292	1,088
Corn	250	--	--	--	3,500	292	970
Milo	200	--	25	--	3,500	292	849
Rice	180	--	25	--	3,500	292	752
Soybeans	60	--	25	--	2,500	292	121
Cyprus/Tupelo[8]	--	--	--	--	--	--	--
Shrub Swamps[8]	--	--	--	--	--	--	--
BLHW[9]							
25-34	--	27	22.5[10]	13.7	3,500	292	64
35-44	--	35	22.5	13.7	3,500	292	103
45-54	--	44	22.5	13.7	3,500	292	146
55-64	--	53	22.5	13.7	3,500	292	190
65-74	--	62	22.5	13.7	3,500	292	234
75-84	--	71	22.5	13.7	3,500	292	277
≥ 85	--	80	22.5	13.7	3,500	292	321

[1] Kg/ha. In all land use categories 50 kg/ha of food is considered left in the field due to decreases foraging efficiency at low food densities.
[2] Harvested but not fall plowed or tilled fields.
[3] Assigned same available energy values as dominate land use.
[4] Aquatic invertebrates including isopods, snails, and fingernail clams.
[5] Kcal of energy/kg of available food.
[6] Kcal/duck/day.
[7] Areas comprised of native moist soil plants. Includes native/improved pasture, set-aside acres, and fallow fields.
[8] Cyprus/tupelo and shrub swamps have limited food values for wintering waterfowl compared to primary foraging habitats.
[9] BLHW (bottomland hardwoods) expressed in terms of percent composition of red oaks. Stand with fewer than 25 percent red oaks are assumed to have minimal food values for wintering waterfowl.
[10] Moist soil seeds associated with forest openings.

In recent years timber harvesting has increased in the project area due to a three-fold increase in hardwood timber prices. Some conversion of forested sites to grassland will also occur; however, this loss would be relatively minor with most land remaining dedicated to commercial forestry practices. Overall, it is estimated that there would be an approximately 30 percent decrease in bottomland hardwood and pine-hardwood forested habitats over the life of the project. However, the bulk of the bottomland hardwoods (approximately 25 percent) will revert to a regeneration or shrubland stage, while about five percent will be converted to grassland. No significant changes are expected in the acreages of agriculture, cypress swamp, riverine/riparian, or open water cover types (U.S. Fish and Wildlife Service 1992).

The Service has evaluated the impacts of the Shreveport to Daingerfield reach by quantifying changes in the amount and quality of available wintering waterfowl foraging habitat resulting from project implementation. These changes were derived from hydrological and GIS data provided by the Corps. Additional detail concerning impact calculations is available upon request from the Service's Vicksburg, Mississippi, Ecological Services office.

Construction Impacts

The study area is at the western periphery of the range of bottomland hardwoods and cypress swamps within the United States, and is nationally recognized as a significant natural ecosystem. The navigation project would have some adverse impacts on the hydraulic regime of the project area by alteration of the current water regimes and levels in the numerous sloughs and backwaters along Cypress and Twelvemile Bayous. Changes in water levels of the basin could result in the mortality of forest vegetation or a change in the species composition of the forest community (U.S. Fish and Wildlife Service 1991). Long term increases in water levels and inundation could kill desirable mast producing hardwood trees such as red oak, willow oak, and water oak which are extremely important to wintering waterfowl for food and cover. These changes would significantly impact the functional value of the wetlands in the area.

Specific to wintering waterfowl, construction impacts are those impacts consisting exclusively of construction and maintenance rights-of-way and dredged material disposal sites. These impacts are "direct" in that an acre-for-acre change in land use occurs.

For existing habitats with values to foraging waterfowl that are projected to be converted to the navigation channel, foraging value would be reduced to zero. However, for those existing foraging habitats that have been or will be converted to borrow pits/spoil disposal area, it is likely some residual foraging value would remain.

Operational Impacts (Changes in Seasonal Flooding)

Project construction and operation would reduce winter flooding in eight of the ten hydrological reaches (the exception being the first and seventh reach). Total acres of available seasonal foraging habitat and foraging duck-days lost, due to project implementation when compared with baseline conditions, are 1,195 and 125,474 respectively (Table 8).

Seasonal acres flooded by land use categories, for all hydrological reaches, include 35,959 acres under baseline conditions and 32,276 acres for the four barge channel (Annex A). Average seasonal duck-day use for, all hydrological reaches, include 286,230 duck-days under baseline conditions and 160,755 duck-days for the four barge channel (Annex B).

CONCEPTUAL MITIGATION MEASURES

Completion of the Shreveport to Daingerfield navigation project would result in wintering migratory waterfowl losses for eight of ten reaches of the authorized four barge channel. The following discussion, which is conceptual, is intended to provide examples of how intensively managing wintering waterfowl on existing public lands can both increase foraging habitat for wintering waterfowl and meet their broader ecological requirements.

Right-of-Way Management and Land Acquisition

The nature of the proposed project and the high quality of the forested and wetland habitats of the Cypress Bayou Basin limits the availability of mitigation options for this project. Since only about 150 acres of the construction right-of-way would be available for reforestation and management, separate mitigation tracts would have to be selected for development and management.

Reforestation

Reforestation is the Service's preferred mitigation technique for several reasons: 1) Reforestation constitutes an ecosystem approach to replacing the waterfowl values that would be lost through project construction. Instead of concentrating on implementing a mitigation feature aimed at primarily replacing the lost food values, reforestation would address all of the waterfowl habitat needs. In this appendix we have used food as an index of waterfowl habitat needs. Waterfowl are not able to divide their world and habitat needs into such neat compartments. A bottomland hardwood forest ecosystem provides food and the other waterfowl habitat needs such as courtship sites, protection from predators and adverse weather, resting and roosting areas, and isolation from human disturbance. 2) Reforestation would provide a stable, low maintenance, high reliability mitigation feature. These mitigation features are supposed to last for the 50 year project life. Other mitigation techniques that would replace lost waterfowl food values, such as moist soil management areas, would require periodic maintenance and/or active operation in order to provide the predicted food supply. With constantly changing funding priorities a "no maintenance-no operation-self sustaining" mitigation feature is much more reliable and cheaper. 3) The chance of successful waterfowl habitat value replacement is highest with reforestation. Reforestation would create a system that would mimic the previously existing bottomland hardwood ecosystem, which had a long term proven record of providing high quality waterfowl habitat. 4) Application of the principles of landscape ecology dictate that we use reforestation as the primary mitigation technique. East Texas has large blocks of open nonforested habitat. The habitat that

TABLE 8
DECREASE IN AVAILABLE SEASONAL FORAGING HABITAT
AND DUCK-DAYS FOR INDIVIDUAL REACHES

Hydrological Reach	Baseline	Four Barge Alternative
Soda Lake Area (Mile 17.6 - 22.2)	74[1] 7,770[2]	148[3] 15,540
Caddo Lake: (Mile 23.1 - 43.6)	195 20,475	40 4,200
Caddo Lake: (Mile 43.6 - 51.9)	394 41,370	255 26,775
Hwy 43 to Jefferson: (Mile 51.9 - 64.0)	1,511 158,655	848 89,040
Hwy 43 to Jefferson: (Mile 64.0 - 67.1)	21 2,205	0 0
Hwy 43 to Jefferson: (Mile 67.1 - 70.2)	33 3,465	0 0
Jefferson to LOP: (Mile 70.2 - 73.7)	39 4,095	197[3] 20,685
Jefferson to LOP: (Mile 73.7 - 77.2)	151 15,855	28 2,940
Jefferson to LOP: (Mile 77.2 - 80.7)	248 26,040	15 1,575
Jefferson to LOP: (Mile 80.7 - 84.2)	60 6,300	0 0
TOTALS	2,726 286,230	1,531 160,755
NET ANNUAL LOSSES		1,195 125,475

[1] Acres of available winter foraging habitat.
[2] Annual duck-days.
[3] Increase due to pool effect.

is most lacking is large blocks of forests. In order to establish landscape diversity, that is the element that we should seek to establish. 5) Reforestation would also offset terrestrfal and wetland losses. 6) Reforestation of marginal agricultural or other cleared lands is easily accomplished. Adequate Corps inhouse experience exists, as it does with USDA, SCS technical assistance personnel, and Texas State Forestry Commission personnel. Actions required include direct seeding or planting seedlings and other activities ranging from extensive mowing and fertilization to only seed bed preparation.

Predicated on the assumption that any reforested acres are subject to. frequent and sustained winter flooding, Table 9 is the Service's estimated available food, available energy, daily energy requirements, and duck-day use per acre for reforested lands annualized over a 50 year period. Forest stand composition should intentionally favor heavy seeded species dominated by red oaks for maximum benefits to wintering waterfowl. Prior to completing mitigation planning for the Shreveport to Daingerfield project, the annual average duck-days per acre in Table 7 must be subtracted from those in Table 9 for each acre reforested.

Based on costs recently developed by the Service and the Corps, seed bed preparation for either direct seeding or planting seedlings amounts to approximately $10 per acre. Depending upon the availability of seeds or seedlings, planting costs per acre range from $75 to $100, respectively including labor and materials. Annual operation and maintenance costs vary from $1 to $20 per acre depending on the intensity of management efforts. Benefits could be expected immediately due to the presence and availability of native moist soil plants in the newly planted "forest" and would gradually change to those benefits associated with forests dominated by red oaks and the associated invertebrate community (Table 9).

Additional detail concerning initial development and annual management of moist soil areas or reforestation can be found in the Service's Waterfowl Management Handbook, Fish and Wildlife Leaflet 13, or through the Office of Information Transfer at the Service's National Ecology Research Center in Ft. Collins, Colorado. Further, the Corps of Engineers, Vicksburg District can be contacted concerning their ongoing reforestation efforts on the "Lake George Property" in the Lower Yazoo Basin, Mississippi.

Spoil Disposal Areas

Benefits could be realized from location and configuration of dredged material disposal areas depending upon size, maintenance dredging requirements, and soil fertility. Benefits would primarily be limited by the size of individual disposal areas and the practicability and cost effectiveness of using space within the areas for establishment of wintering waterfowl foraging habitat in addition to the disposal of dredged material.

TABLE 9

LAND USE, AVAILABLE FOOD, AVAILABLE ENERGY, DAILY ENERGY REQUIREMENTS, AND DUCK-DAY USE PER ACRE ON REFORESTED MARGINAL AGRICULTURAL LANDS

Land Use	Available Food 1/ Crop Residue	Red Oak Acorns	Weed Seed 2/	Invertebrates 3/	Average Available Energy 4/	Daily Energy Requirements 5/	Annual Duck Days Acre
BLHW							
55-64 7/	--	25 6/	127 6/	13.7	3,500	292	561
65-74	--	29	127	13.7	3,500	292	581
75-84	--	34	127	13.7	3,500	292	605
≥ 85	--	38	127	13.7	3,500	292	625

1/ Kg/ha. In the duck-day calculations 50 kg/ha of food is considered left in the field due to decreased foraging efficiency at low food densities.

2/ Assigned efficiency at low food densities.

3/ Aquatic invertebrates including isopods, snails, and fingernail clams.

4/ Kcal of energy/kg of available food.

5/ Kcal/duck/day.

6/ Annualized value over 50 years.

7/ Percent red oaks.

The lowest area within a disposal area could be dedicated to the maintenance or establishment of moist soil plants of benefit to waterfowl. In other instances topsoil with the boundaries of a disposal area could be stockpiled and then spread over the dredged material enabling natural establishment of moist soil plants. Either possibility could be negated by future dredged material disposal during maintenance operations. Nevertheless, existing disposal areas and future disposal requirements should be carefully reviewed to determent the opportunities for establishment or maintenance of wintering waterfowl habitats.

Average Annual Benefits

Mitigation values achieved would vary depending on the land type established or improved. From Tables 7 and 9, average annual duck-&y use within the Shreveport to Daingerfield Project area could be expected to range from 1,088 days per acre for a moist soil area exclusively devoted to wintering waterfowl, to a low of 121 days per acre for a flooded harvested soybean field that has not been fall plowed or burned. Depending on topography and soil types, reforested areas dominated by red oaks could be expected to average from 561 to 625 annual duck-days per acre.

It is uncertain that appreciable wintering waterfowl benefits could be provided in dredge material disposal areas. For planning purposes, benefits should not be anticipated unless the acreage of an individual disposal area or the cumulative acreage of an individual disposal area and other adjacent areas developed or maintained for foraging habitat approach ten acres.

In addition to food values, other benefits to wintering waterfowl would also be realized from the establishment or enhancement of forested wetlands. Benefits would include isolation for pair bonding, better protection from disturbance and harassment than in more open areas, and protection from predation and extremes in weather conditions.

Unquantified benefits resulting from establishment of more dependable wintering waterfowl foraging habitat accrue to the whole range of resident and migratory species attracted to wetlands as well as overall wetland functional values. Not intended as all inclusive, the list of fauna benefiting would include resident aquatic furbearers, resident and migrant shore and water birds, insectivorous and seed eating neotropical birds, native amphibians and reptiles, and the broad range of resident game and nongame birds and mammals known to spend time in forested wetlands and non-wooded wetlands such as moist soil areas.

Other functional wetland values would include flood storage, water quality attributes, ground water recharge, esthetics, and scientific study opoortunities. Additionally, economic benefits would result from added outdoor recreation opportunities and the harvest of timber and other wood products. Economic losses could result in those instances where existing agricultural practices/leases might have to be modified.

CONCLUSION

Implementation of the proposed four barge navigation channel would result in severe adverse impacts to wintering migratory waterfowl. Losses would occur both on private and public lands and would be evident in eight out of ten of the hydrological reaches. Wintering foraging carrying capacity would be reduced annually by 125,475 duck-days. Those losses would occur in one of the primary waterfowl wintering areas in east Texas.

The losses just described are of concern to the Service not only because of the adverse impacts upon migratory waterfowl, a federal trust resource, but also because of the adverse impacts to the project area ecosystem. It is doubtful if losses to the unique Cypress Bayou basin ecosystem could be properly mitigated for considering the high quality of the wetlands found there and the magnitude of the project.

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TABLE A-1

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR SODA LAKE AREA (MILE 17.6 - 22.2) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
Soda Lake Area (Mile 17.6 - 22.2)	243[1]
	362[2]
Bottomland Hardwoods	74
	148
Riverine	139
	174
Water	20
	21
Other[3]	10
	19

[1/]Baseline
[2/]Original Four Barge Channel
[3/]Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-2

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR CADDO LAKE: SUB-REACH 1 (MILE 23.1 - 43.6) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
Caddo Lake: Sub-Reach 1 (Mile 23.1 - 43.6)	22,991[1]
	22,215[2]
Bottomland Hardwoods	195
	40
Cypress/Tupelo	644
	590
Water	21,551
	21,535
Other[3]	601
	50

1/Baseline
2/Original Four Barge Channel
3/Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-3

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR CADDO LAKE SUB-REACH 2 (MILE 43.6 - 51.9) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
Caddo Lake: Sub-Reach 2 (Mile 43.6 - 51.9)	6,942[1]
	6,426[2]
Bottomland Hardwoods	394
	255
Cypress/Trpelo	4,219
	4,168
Water	1,603
	1,588
Other[3]	726
	415

[1/]Baseline
[2/]Original Four Barge Channel
[3/]Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-4

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR HWY 43 TO JEFFERSON: SUB-REACH 1 (MILE 51.9 - 64.0) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
HWY 43 to Jefferson: Sub-Reach 1 (Mile 51.9 - 64.0)	4,478[1]
	3,067[2]
Bottomland Hardwoods	1,511
	848
Cypress/Tupelo	1,243
	1,130
Water	347
	333
Other[3]	1,377
	756

[1]/Baseline
[2]/Original Four Barge Channel
[3]/Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-5

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR HWY 43 TO JEFFERSON: SUB-REACH 2 (MILE 64.0 - 67.1) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
HWY 43 to Jefferson: Sub-Reach 2 (Mile 64.0 - 67.1)	49[1]
	0[2]
Bottomland Hardwoods	21
	0
Cypress/Tupelo	8
	0
Water	0
	0
Other[3]	20
	0

[1/]Baseline
[2/]Original Four Barge Channel
[3/]Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-6

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR HWY 43 TO JEFFERSON: SUB-REACH 3 (MILE 67.1 - 70.2) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
HWY 43 to Jefferson: Sub-Reach 3 (Mile 67.1 - 70.2)	107[1]
	0[2]
Bottomland Hardwoods	33
	0
Cypress/Tupelo	17
	0
Water	0
	0
Other[3]	57
	0

[1/]Baseline
[2/]Original Four Barge Channel
[3/]Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-7

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR JEFFERSON TO LOP SUB-REACH 1 (MILE 70.2 - 73.7) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 1 Mile 70.2 - 73.7)	439[1]
	130[2]
Bottomland Hardwoods	197
	39
Cypress/Tupelo	69
	14
Water	53
	53
Other[3]	120
	24

[1/]Baseline
[2/]Original Four Barge Channel
[3/]Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-8

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR JEFFERSON TO LOP SUB-REACH 2 (MILE 73.7 - 77.2) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 2 Mile 73.7 - 77.2)	314[1]
	46[2]
Bottomland Hardwoods	151
	28
Cypress/Tupelo	31
	9
Water	0
	0
Other[3]	132
	9

[1]/Baseline
[2]/Original Four Barge Channel
[3]/Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-9

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR JEFFERSON TO LOP SUB-REACH 3 (MILE 77.2 - 80.7) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 3 Mile 77.2 - 80.7)	546[1]
	30[2]
Bottomland Hardwoods	248
	15
Cypress/Tupelo	29
	4
Water	11
	2
Other[3]	258
	9

[1]/Baseline
[2]/Original Four Barge Channel
[3]/Includes cotton, pasture, and other miscellaneous land use categories

TABLE A-10

ADJUSTED SEASONAL AVERAGE ACRES FLOODED BY LAND USE CATEGORIES: BASELINE CONDITIONS AND CONDITIONS FOR JEFFERSON TO LOP SUB-REACH 4 (MILE 80.7 - 84.2) UPON COMPLETION OF ORIGINAL FOUR BARGE CHANNEL

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 4 Mile 80.7 - 84.2)	93[1]
	0[2]
Bottomland Hardwoods	60
	0
Cypress/Tupelo	7
	0
Water	0
	0
Other[3]	26
	0

1/Baseline
2/Original Four Barge Channel
3/Includes cotton, pasture, and other miscellaneous land use categories

TABLE B-1

ADJUSTED SEASONAL DUCK DAY USAGE: BASELINE CONDITIONS AND CONDITIONS FOR SODA LAKE AREA (MILE 17.6 - 22.2)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Soda Lake Area (Mile 17.6 - 22.2)	7,770[1]
	15,540[2]
Bottomland Hardwoods	7,770
	15,540
Riverine	NA
Water	NA
Other	NA

[1/]Baseline
[2/]Original Four Barge Channel

TABLE B-2

ADJUSTED SEASONAL DUCK DAY USAGE: BASELINE CONDITIONS AND CONDITIONS FOR CADDO LAKE SUB-REACH 1 (MILE 23.1 - 43.6)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Caddo Lake: Sub-Reach 1 (Mile 23.1 - 43.6)	20,475[1]
	4,200[2]
Bottomland Hardwoods	20,475
	4,200
Cypress/Tupelo	NA
Water	NA
Other	NA

[1/]Baseline
[2/]Original Four Barge Channel

TABLE B-3

ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
CADDO LAKE SUB-REACH 2 (MILE 43.6 - 51.9)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Caddo Lake: Sub-Reach 2 (Mile 43.6 - 51.9)	41,370[1]
	26,775[2]
Bottomland Hardwoods	41,370
	26,775
Cypress/Tupelo	NA
Water	NA
Other	NA

[1/]Baseline
[2/]Original Four Barge Channel

TABLE B-4

ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
HWY 43 TO JEFFERSON: SUB-REACH 1 (MILE 51.9 - 64.0)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 1 (Mile 51.9 - 64.0)	158,655[1]
	89,040[2]
Bottomland Hardwoods	158,655
	89,040
Cypress/Tupelo	NA
Water	NA
Other	NA

[1/]Baseline
[2/]Original Four Barge Channel

TABLE B-5

ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
HWY 43 TO JEFFERSON: SUB-REACH 2 (MILE 64.0 - 67.1)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 2 (Mile 64.0 - 67.1)	2,205[1]
	0[2]
Bottomland Hardwoods	2,205
	0
Cypress/Tupelo	NA
Water	NA
Other	NA

[1]/Baseline
[2]/Original Four Barge Channel

TABLE B-6

ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
HWY 43 TO JEFFERSON: SUB-REACH 3 (MILE 67.1 - 70.2)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 3 (Mile 67.1 - 70.2)	3,465[1]
	0[2]
Bottomland Hardwoods	3,465
	0
Cypress/Tupelo	NA
Water	NA
Other	NA

[1]/Baseline
[2]/Original Four Barge Channel

TABLE B-7

**ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
Jefferson to LOP: SUB-REACH 1 (MILE 70.2 - 73.7)**

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 1 (Mile 70.2 - 73.7)	4,095[1]
	20,685[2]
Bottomland Hardwoods	4,095
	20,685
Cypress/Tupelo	NA
Water	NA
Other	NA

[1]Baseline
[2]Original Four Barge Channel

TABLE B-8

**ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
Jefferson to LOP: SUB-REACH 2 (MILE 73.7 - 77.2)**

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 2 (Mile 73.7 - 77.2)	15,855[1]
	2,940[2]
Bottomland Hardwoods	15,855
	2,940
Cypress/Tupelo	NA
Water	NA
Other	NA

[1]Baseline
[2]Original Four Barge Channel

TABLE B-9

ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
Jefferson to LOP: SUB-REACH 3 (MILE 77.2 - 80.7)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 3 (Mile 77.2 - 80.7)	26,040[1]
	1,575[2]
Bottomland Hardwoods	26,040
	1,575
Cypress/Tupelo	NA
Water	NA
Other	NA

[1/]Baseline
[2/]Original Four Barge Channel

TABLE B-10

ADJUSTED SEASONAL DUCK DAY USAGE:
BASELINE CONDITIONS AND CONDITIONS FOR
Jefferson to LOP: SUB-REACH 4 (MILE 80.7 - 84.2)

REACH/LAND USE	NOVEMBER -- FEBRUARY
Jefferson to LOP: Sub-Reach 4 (Mile 80.7 - 84.2)	6,300[1]
	0[2]
Bottomland Hardwoods	6,300
	0
Cypress/Tupelo	NA
Water	NA
Other	NA

[1/]Baseline
[2/]Original Four Barge Channel

Red River Waterway Project
Shreveport, LA, to Daingerfield, TX, Reach
Reevaluation Study In-Progress Review

APPENDIX 6
AQUATIC RESOURCES

RED RIVER WATERWAY PROJECT
SHREVEPORT, LA, TO DAINGERFIELD, TX
REEVALUATION STUDY IN-PROGRRSS REVIEW

APPENDIX 6
AQUATIC RESOURCES

<u>**Item**</u>

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REEVALUATION STUDY IN-PROGRESS REVIEW

APPENDIX 6
AQUATIC RESOURCES

INTRODUCTION

1. Ichthyofauna of the Cypress Bayou and Twelvemile Bayou system is diverse and unusual. Over 80 species are documented from Big Cypress Bayou and its principal tributaries, many of which are rare and/or at the westernmost limits of their distribution (Hoover et al., in press). Fish communities of Twelvemile Bayou are poorly documented, but are potentially complex because of the high species richness of the Lower Red River (Cross et al., 1986).

2. Evaluating impacts of the proposed Red River Waterway, Shreveport to Daingerfield Reach, on fish habitat required a priority consideration of fauna1 complexity and composition, as well as availability of quantitative habitat models. Local fish assemblages are taxonomically dominated by darters and minnows, and to a lesser extent by sunfishes, exploiting a wide variety of habitats and microhabitats. In lowland streams of the southeast, and especially in blackwater systems, these habitats are defined primarily by hydraulic parameters (velocity and depth) and instream structure (vegetation and woody cover), and fishes exhibit a high degree of habitat specialization (e.g., Baker and Ross, 1981; Meffe and Sheldon, 1988). Quantitative models, like the Habitat Suitability Index (HSI), however, are unavailable for the majority of species characteristic of this system.

3. To determine best methods of habitat assessment, meetings were held in August and December 1992 among cooperating agencies: Texas Parks and Wildlife; Louisiana Wildlife and Fisheries Commission; U.S. Fish and Wildlife Service (FWS); and U.S. Army Corps of Engineers, Vicksburg District (CELMK), and Waterways Experiment Station (CEWES). Decisions of the interagency team were: (1) reservoirs would be modeled separately from streams using regression equations developed by the National Reservoir Research Program, WS; (2) streams would be modeled using Instream Flow Incremental Methodology; (3) evaluation species would be chosen from different ecological guilds to broaden representation of the fish community; (4) existing models of stream fish-habitat relationships (i.e., suitability indices) would be used, with modifications based on field data from this study.

4. Ecological guilds were constructed for the known ichthyofauna based on spawning and velocity preferences of individual species (Table 6-1), providing the principal basis for selecting evaluation species. Additional criteria considered included: commercial and recreational importance, sensitivity to environmental disturbances, and availability of existing habitat models (e.g., Killgore and Hathorn, 1987). Habitat assessments were conducted separately for

Table 6-1
Habitat guilds for Cypress and Twelvemile Bayou fishes, based on preferred velocities (horizontal axis! and spawning substrate (vertical axis). Evaluation species for reservoirs (*) and streams (**) are indicated.

	LACUSTRINE/GENERALISTS	SLACK WATER	SWIFT WATER
OPEN	Gizzard shad Mosqultoflsh	American eel * Threadfin shad Cypress minnow Silvery minnow Ribbon shiner	Skipjack herring Emerald shiner Mimic shiner Freshwater drum
SAND AND GRAVELS	Red shiner Green sunfish Orangespotted sunfish * Bluegill Redear sunfish * Lsrgemouth bass White Crappie Black crappie	Redfin shiner Pallid shiner Bluehead shiner Pugnose minnow River carpsucker Creek chubsucker ** Spotted sucker Blacktail redhorse Golden topminnow Flier Warmouth Redbreast sunfish Dollar sunfish Longear sunfish Spotted sunfish Bantam sunfish ** Spotted bass Mud darter	Chestnut lamprey Blackspot shiner Striped shiner ** Ironcolor shiner Sand shiner Weed shiner Yellow bass White Bass Scaly sand darter Harlequin darter Goldatripe darter Redfin darter River darter ** Blackside darter Dusky darter
VEGETATION	Bowfin Common carp Golden shiner Brook silverside	* Spotted gar Shortnose gar Alligator gar ** Grass pickerel ** Chain pickerel Taillight shiner Lake chubsucker Smallmouth buffalo Bigmouth buffalo Starhead topminnow Blackstripe topminnow Blackspotted topminnow Inland silverside Banded pygmy sunfish ** Bluntnose darter Swamp darter Slough darter	Longnose gar Black buffalo
CREVICE	Bullhead minnow Black bullhead Yellow bullhead * Channel catfish	Blue catfish Tadpole madtom ** Flathead catfish Pirate perch Cypress darter	** Blacktail shiner

streams and lakes. Data arc summarized for three navigational reaches: Twtlvc-mile Bayou (I), Big Cypress Bayou below Jefferson, Texas including Caddo Lake (II), Big Cypress Bayou above Jefferson, Texas including L&t 0' the Pints (III).

5. The objectives of this report art: (1) establish baseline conditions for ichthyofauna and physical habitat; (2) apply habitat evaluation techniques and quantify impacts of the proposed waterway on fish habitat.

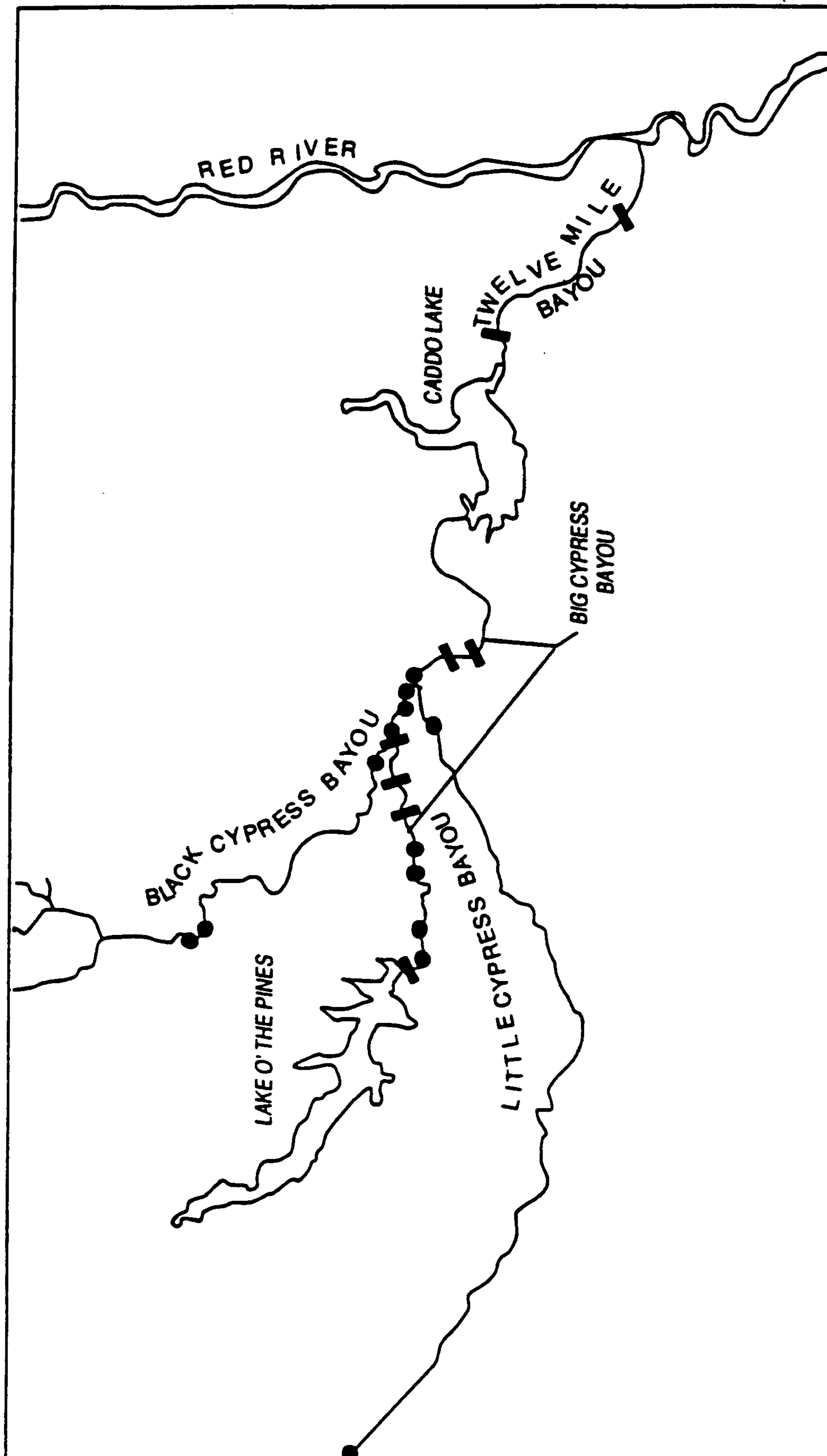
STUDY AREA

6. The study area extends from the mouth of Twelvemile Bayou to the upper reaches of Lake 0' The Pints (Figure 1). The system consists of blackwater streams, lakes, and swamps located in Cass, Marion, Harrison, Morris, Titus, and Upshur Counties, Texas, and Caddo Parish, Louisiana. Soils art alluvial, mainly loamy sand with low-to-moderate organic matter. Dominant riparian vegetation includes bald cypress (*Taxodium distichum)*, button bush (*Cephalanthus occidentalis)*, common alder (*Alnus serrulata*), water elm (*Planera aquatica)*, and black willow (*Salix nigra)*. In the rivers, aquatic plants art patchy in distribution. Water moss (*Fontinalis* sp.) is attached to submerged tree bases and fallen trees. Water lilies *(Nymphaea odorata) occur* during the summer in wide, shallow backwaters in the lower reaches. Substrate in the rivers ranges from clayey sand to silty clay. Allochthonous material (primarily leaf litter) usually overlays the sediment in slackwater.

7. Lake 0' The Pints was initially impounded in 1957 for flood control, recreation, and water supply. Water supply pool area is 18,700 acres. Maximum depth is 45 feet. Inundated brush and timber art common in the middle and upper areas of the lake, and shorts art shallow and sandy; lower reaches have steep rock outcroppings or sloping banks of clay or sandy loam with growths of button bush and black willow. Aquatic vegetation is moderately abundant, comprised mainly of American lotus *(Nelumbo lutea)* and water-weed (*Elodea* sp.).

8. Big Cypress Bayou,between Lake 0' The Pints and Caddo Lake, is 40 milts long. Discharge is largely controlled by releases from Lake 0' the Pints with input from tributaries and local runoff after heavy rains. The lower reach below Jefferson, Texas, has been channtlized and was historically navigable by steamship. The channtliztd reach of Big Cypress Bayou is wide (125-300 feet), deep (to 40 ft), with little instream cover except cypress knees. The upper reach is shallow, meandering, with submerged logs and riparian vegetation. The principal tributaries of Big Cypress Bayou art two blackwater streams: Black Cypress Bayou and Little Cypress Bayou.

9. Caddo Lake was formed by a log jam on the Red River during the 19th century. In 1914, an earthen dam was constructed which was replaced by a concrete structure in 1971. Conservation pool area is 26,800 acres with an average depth of about 6 feet. Over 30 species of aquatic plants occur in the lake; water hyacinth (Eichomia crassipes), coontail (Ceratophyllum demersum), and Eurasian watermilfoil (Myriophyllum spicatum) dominate the upper portion of the lake. Cypress trees form extensive stands throughout.


RED RIVER
TWELVE MILE BAYOU
CADDO LAKE
BIG CYPRESS BAYOU
BLACK CYPRESS BAYOU
LITTLE CYPRESS BAYOU
LAKE O' THE PINES

10. Twelvemile Bayou is 23 miles long. It is wide (250-300 feet), deep (16 feet) and was historically navigable. Shorelines are sandy with steep, wooded bluffs. Banks are highly erodible, compared with Big Cypress Bayou. Instream cover consists of fallen trees and debris. Aquatic plants are rare.

RESERVOIR IMPACT ANALYSIS

11. Five evaluation species were selected: spotted gar (Lepisosteus oculatus), threadfin shad *(Dorosoma petenense)*, channel catfish *(Ictalurus punctatus)*, bluegill (*Lepomis macrochirus*), and largemouth bass *(Micropterus salmoides)*. These species represent four different ecological guilds comprised-of 34 species (Table 6-l). Habitat models used are regressions developed from field data conducted for National Reservoir Research Program (Ploskey et al., 1986). In these models, observed standing crops of fishes (dependent variable) are significantly correlated with physical variables such as water quality, lake morphometry, and growing season (independent variables).

METHODS

12. Regression models were used to calculate estimated standing crops of fish (Ploskey et al., 1986). Several models were available, but since lake morphometry will not change appreciably as a result of the proposed waterway, models were selected that equated standing crops with physical (water quality) and nutrient data:

Gar = -13.627 - 1.288 Log(Secchi depth) - 2.571 log(Nitrogen) + 5.882 log(Growing season) r2 = 0.31

Threadfin shad = 2.016 + 1.109 Log(Secchi depth) + 1.639 log(Phosphorous) r2 = 0.11

Catfish = 0.987 + 0.350 log(Phosphorus) I 0.275 log(Alkalinity) r2 = 0.12

Bluegill = 1.519 ı 0.942 log(Secchi depth) + 0.668 Log (Phosphorus) - 0.162 log(Storage ratio) r2 = O.-I9

Largemouth bass= -4.109 ı 0.326 log(Secchi depth) ı 0.548 Log (Chlorophyll a) ı 1.869 log(Growing season) r2 = 0.29

13. Water quality data from CELMK were used to calculate estimated standing crops of fish. Preproject standing crops were calculated from mean values for water quality parameters sampled in 1991-1992. Long-term changes in water quality attributable to the project were not anticipated based on the water quality data collected by CELMK.

	Caddo Lake	Lake O' The Pines
Secchi depth (ft)	2.1	2.2
Nitrogen (ppm)	.702	.810
Phosphorus (ppm)	.056	.060
Growing season (days)	230	230
Alkalinity (ppm)	14	20
Chlorophyll a (ppb)	29	9
Storage ratio (yp)	.10	.44

ASSUMPTIONS

14. Spotted gar and channel catfish are the dominant representatives in their families. Regression models were available for gars and catfishes, but not for individual species (Ploskey, et al., 1986). The models have the greatest chance of representing habitat of individual species, then, when a single species is numerically dominant. Reservoir surveys indicate that spotted gars are substantially more abundant than longnose gars, and that channel catfish dominate biomass more than flathead catfish and bullheads (Dorchester, 1959: Toole and Ryan, 1981; Toole, 1983).

RESULTS AND DISCUSSION

15. Calculations based on water quality and regression models are summarized below:

ESTIMATED STANDING CROPS (LBS/ACRE)

	Spotted Gar	Threadfin Shad	Channel Catfish	Bluegill	Largemouth Bass
Caddo Lake	0.24	0.51	1.11	1.15	1.21
Lake O' The Pines	0.06	0.60	0.92	1.08	0.94

16. Regression equations identified relevant variables associated with .habitat value, and estimated standing crops provided indices of relative abundance and habitat quality for individual species. In the southeast, secchi depth (i.e., transparency) and/or phosphorus were significantly correlated with standing crops of each of the five evaluation species (Ploskey et al., 1986), suggesting that habitat quality of Caddo Lake and Lake 0'The Pines will be influenced by primary productivity. Estimated standing crops indicated higher abundances (and habitat quality) in both reservoirs for channel catfish, bluegill, and largemouth bass, than for gar or threadfin shad. Rotenone surveys of the two lakes confirm this pattern in relative abundance, although observed standing crops were substantially higher than estimated standing crops (Toole and Ryan, 1981; Toole, 1983; unpublished data of Texas Parks and Wildlife Department). Because no long-term, project-related changes in water quality are anticipated, changes in fish habitat were undetectable.

STREAM IMPACT ANALYSIS

17. Eight evaluation taxa were selected: pickerels (Esox spp.), blacktail shiner *(Cyprinella venusta),* ironcolor shiner (*Notropis chalybaeus*), spotted sucker (Minytrema melanops), flathead catfish *(Pylodictis olivaris),* spotted bass (*Micropterus punctulatus),* bluntnose darter (*Etheostoma chlorosomum*), and blackside darter *(Percina maculata). These* species represent five ecological guilds comprised by 56 species (Table 6-l). Habitat models were previously developed from field data on local populations of five species (Killgore and Hathorn, 1987) Literature-based models are available for flathead catfish (Killgore and Hathorn, 1987; Lee and Terrell, 1987). A non-regional model is available for the slough darter (*Etheostoma gracile),* a species with habitat requirements similar to the bluntnose darter (Edwards etal., 1982; Kuehne and Barbour, 1983). Limited unpublished data exist for the blackside darter (Thorn Hardy, pers. comm.).

METHODS

18. Fish-habitat relationships - Physical habitat and relative abundance of fishes were sampled at 21 stations April-August 1992 (Figure 1). Four stations were sampled on four occasions, 13 stations on three occasions, and five stations once. During sampling, stream width, dissolved oxygen, Ph. turbidity, conductivity, and temperature were measured from a single position representative of that station; measurements were made with a Lietz rangefinder, Hydrolab, and Hach 2100 turbidimeter. Depth and velocity were measured at 10 points along a cross-sectional transect; depth was measured using a stadia rod (< 15 feet) or Hummingbird boat mounted depth-finder (> 15 feet); velocity was measured using a Marsh-McBirney velocity meter, the probe at 0.6 depth (< 3 ft.) or 0.2 and 0.8 depth (> 3 feet). If substantial longitudinal variation existed at a site, additional transects were used.

19. Fishes were collected using a seine (10 X 8 ft., 3/8" mesh); a representative effort consisted of 10 hauls through all apparent habitats. When depths were sufficient (> 6 feet), experimental gillnets (6 X 90 feet, .75, 1.5, 2.0, 2.5, 3.0, 3.5" mesh) were set out overnight.

20. Because habitat models did not exist for the blackside darter, and because this species is uncommon locally, 10 individuals collected from Big Cypress Bayou were transported to a 4- by B-foot laboratory stream (265 gallons) at Northeast Louisiana University, Department of Biology. The stream created a mosaic of velocities ranging from O-l.3 feet/second. A hydraulic map was constructed **from** approximately 100 velocity measurements along cross-sectional transects throughout the stream. Measurements were made 0.2 inches from the bottom (height occupied by a darter resting on the bottom) using a Nixon 422 velocity meter and probe. Contours were constructed for ranges at 2 inches/s intervals. Observations of darter position were made 10 times/day for 6 weeks and used to infer occupied velocities.

21. Suitability indices (SI's) for physical habitat variables were confirmed, modified, or generated by plotting standardized number of observations (i.e., fish) for each measured value of a variable (i.e., velocity, depth, cover). Observed SI's were compared with existing SI curves. Because few flathead catfish were collected, previously developed curves were used for stream habitat (Killgore and Hathorn, 1987). SI curves were distributed to all members of the interagency fish-habitat team for comment.

22. Instream Flow Incremental Methodology (IFIM) - Direct effects of the waterway on channel habitat were evaluated by simulating changes in habitat that would occur at different discharges. Standard field surveys (Bovte and Milhous, 1978; Bovee, 1982) of water surface elevation, bottom contours, water velocity, and occurrence of instream cover were conducted along l-4 transects at seven sites: preproject rivermiles 11.0, 22.5, 55.0, 56.0, 62.5, 66.5, 71.0, 82.5 (Figure 1). These represented homogeneous lengths of fish habitat, based on gross river morphometry, and were determined by field reconnaissance.

23. The model was implemented using these cross-sectional data (preproject) and cross-sections based on waterway specifications (post-project) provided by CELMK PHABSIM generated quantitative simulations of physical habitat for a wide range of discharges: 5-5,000 cfs in upper Big Cypress Bayou; 5-8,000 cfs in lower Big Cypress Bayou; 900-36,000 cfs in Twelvemile Bayou (see Bovee., 1982 for computational methodology). For each length of stream, data from simulations (velocity depth, cover) were weighted with corresponding SI's to calculate Weighted Usable Area (WUA) for each species.

24. Discharges used to calculate impacts were those for a "typical" water year (1985). Data provided by CELMK showed median (or near median) discharge for 1985 at all three gages for which the period of record is greater than 25 years. Differences in WUA were calculated for each species, each month (based on mean monthly discharge for that reach); annual means of the differences in WUA for each habitat reach were combined to express overall changes in habitat in each navigational reach.

ASSUMPTIONS

25. Stage-Discharge Ralationships provided by CELMK were used for all analyses. Elevations in NCVD were adjusted to IFI survey elevations. Post-project stage-discharge relationships, provided by CELMK, were derived by adjusting the pre-project relationships by regression for common stage-discharge points on the pre- and postproject curves.

26. Postproject cross sections (HEC-2) and alignment map, provided by CELMK, were used to locate corresponding IFIH stations. At each IFIM station, all HEC-2 cross-sections within +1 mile were utilized in analysis.

27. Cross-section weightings were based on number of transects available for each site (e.g.,a site with 3 cross-sections would have each individual cross-section weighted 33.33% for that length of stream). Cross-sectional data represented a "theoretical" lOO-ft. section of stream.

28. Two-channel conditions were assumed for all cross-sections in which simulated water surface elevation indicated depth in either channel.

29. Velocity profiles from IFIM field surveys were utilized for calibration of pre-project conditions. For measured discharge at each station, velocities were used to estimate Manning's n for each vertical. Manning's n was assumed constant for all other simulated discharges.

30. For postproject HEC-2 cross-sectional data,Manning's n values were assumed and used to simulate velocities. It was assumed that Manning's n did not change as a function of discharge. Calibration discharges and starting water surface elevations were taken from postproject stage-discharge relationships. IFIM data sets contain approximately 2-3 times more verticals versus postproject discharges derived from HEC-2 data sets. This means that preproject velocity simulations will have greater variation in velocity profiles compared to postproject simulations.

31. Reproject cover observed at each vertical was used in all simulations. "No cover" was assumed for postproject cross sections (i.e., conservative assumption).

32. Horizontal extension of IFIM cross-sactfonal field measurements were based on preproject cross-sectional profiles and were used to simulate higher discharges.

33. Habitat simulations used geometric means of depth, velocity, and cover Suitability Indices. This option in the IFIM habitat modeling represents compensatory analysis and was considered the best approach given the uncertainty in the assumed stage-discharge relationships and velocity simulations.

34. Physical habitat is assumed to be of primary importance, whereas temperature and water quality are not limiting.

35. Two-year Flood Impacts - Indirect effects of waterway operation were evaluated by predicting reductions in flood plain habitat. Pre- and postproject water elevations for a 2-year frequency flood (i.e., a flood with a 50 percent chance of occurring in any given year), and river stage-area relationships were _ provided by CELMK. These data were used to generate estimates of changes in flooded acreage. Suitability indices for flood.plains in each navigational reach were created for seven species using the following formula:

$$SI = \frac{\text{Mean Relative Abundance in Reach}}{\text{Mean Relative Abundance in System + One Standard Deviation}}$$

Flathead catfish were not collected in sufficient numbers to determine flood plain SI in this manner, so a value established by expert consensus was used (Killgore and Hoover, 1992). Impacts to fish habitat were determined by multiplying preproject and postproject flooded acres with SI's for each species.

ASSUMPTIONS

36. Two-year flood determines ecological success (e.g., survival, growth, reproduction) of fish. Less frequent (more severe) flooding may be associated with pronounced changes in certain fisheries, but fast-growing and short-lived fishes require more frequent (less severe) flooding for sustained production. Of the eight evaluation species, two are known to be long-lived ($\geq$ 5 years): spotted bass and flathead catfish (Carlander, 1969; Pflieger, 1975; Robison and Buchanan, 1988). Both species, however, may mature by Age 3. Pickerel and spotted sucker do not usually live more than 3-4 years, and the shiners and darters probably _ live only 2-3 years.

37. Flood plain habitats do not differ among the reaches. Flood plain habitats consist almost exclusively of bottomland hardwood wetlands (Hans Williams, pers. comm.. Flooded agricultural land,fallow land, etc. is negligible.

38. All species utilize flood plain. Quantification of flood plain use by southeastern stream fishes is not well-documented in literature, although some species are known to be "exploitative" and others are considered "quiescent" (Ross and Baker, 1983). Flood plain utilization is known for the majority of evaluation species (Kwak, 1988; Killgore and Hoover, 1992). Flood plain use is not documented for spotted bass or blackside darter, although we have encountererd the last species in qualitative collecting. Assumptions that all species use flood plains equally, though, provides a worst-case scenario of possible habitat impacts (i.e., conservative assumption).

39. In-stream relative abundance will reflect primary habitat value of flood plains. We expressed this as a ratio of a typical value (mean) for that reach to a high value for that system (mean + 1 standard deviation). Since flood plain habitats consist of one principal kind, use of that habitat should be dependent on the number of fishes available for lateral migration. i.e., fish

density within that segment of the stream. Physical characteristics of flood plains, chronology, and duration of flooding are presumed secondary in importance. Homogeneity of flood plain habitats, and the prolonged breeding seasons of fishes in this area (e.g., Hubbs, 1985) support this contention.

RESULTS AND DISCUSSION

40. Stations sampled at Twelvemile Bayou had greater velocities and depths than those at Cypress Bayou (Figure 2). Variation in hydraulic parameters within locations and between stations and time was greater for velocity (Coefficient of variation 86-227 percent), than for depth (CV - 46-81 percent) or width (CV- 19-64 percent).

41. Evaluation species were highly variable in abundance. Numbers collected of each evaluation species by seining were:

Pickerels	138
Ironcolor shiner	222
Blacktail shiner	94
Spotted sucker	24
Flathead catfish	2
Spotted bass	45
Bluntnose darter	158
Blackside darter	71

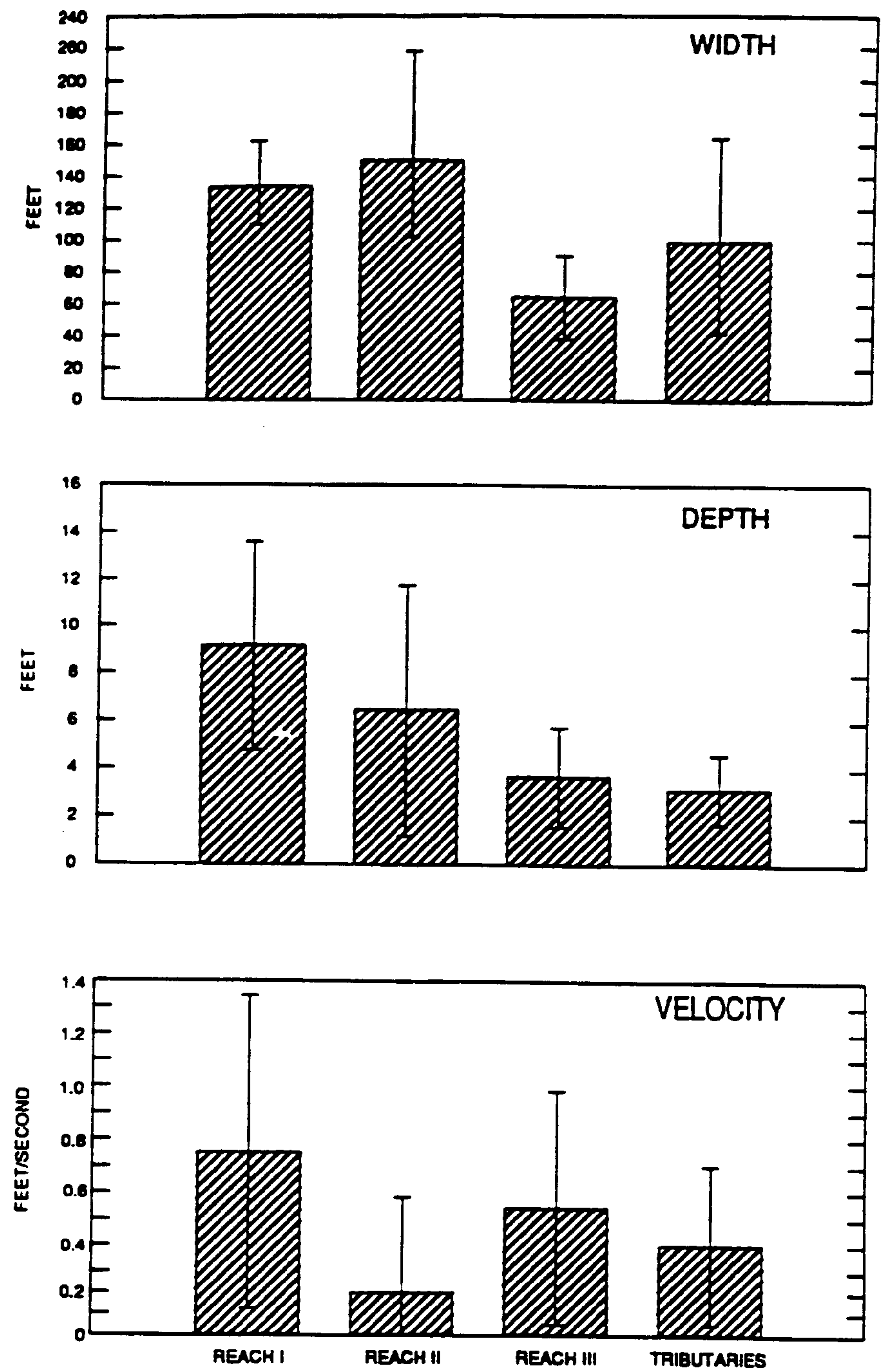
42. Numbers of evaluation species collected by gillnetting were low (< 30) but locations where large fishes were gillnetted corresponded to those where smaller individuals of the same species were seined. High SI's for most species were observed for slow, shallow water with cover (Figure 3) and wetlands of Big Cypress Bayou (Figure 4).

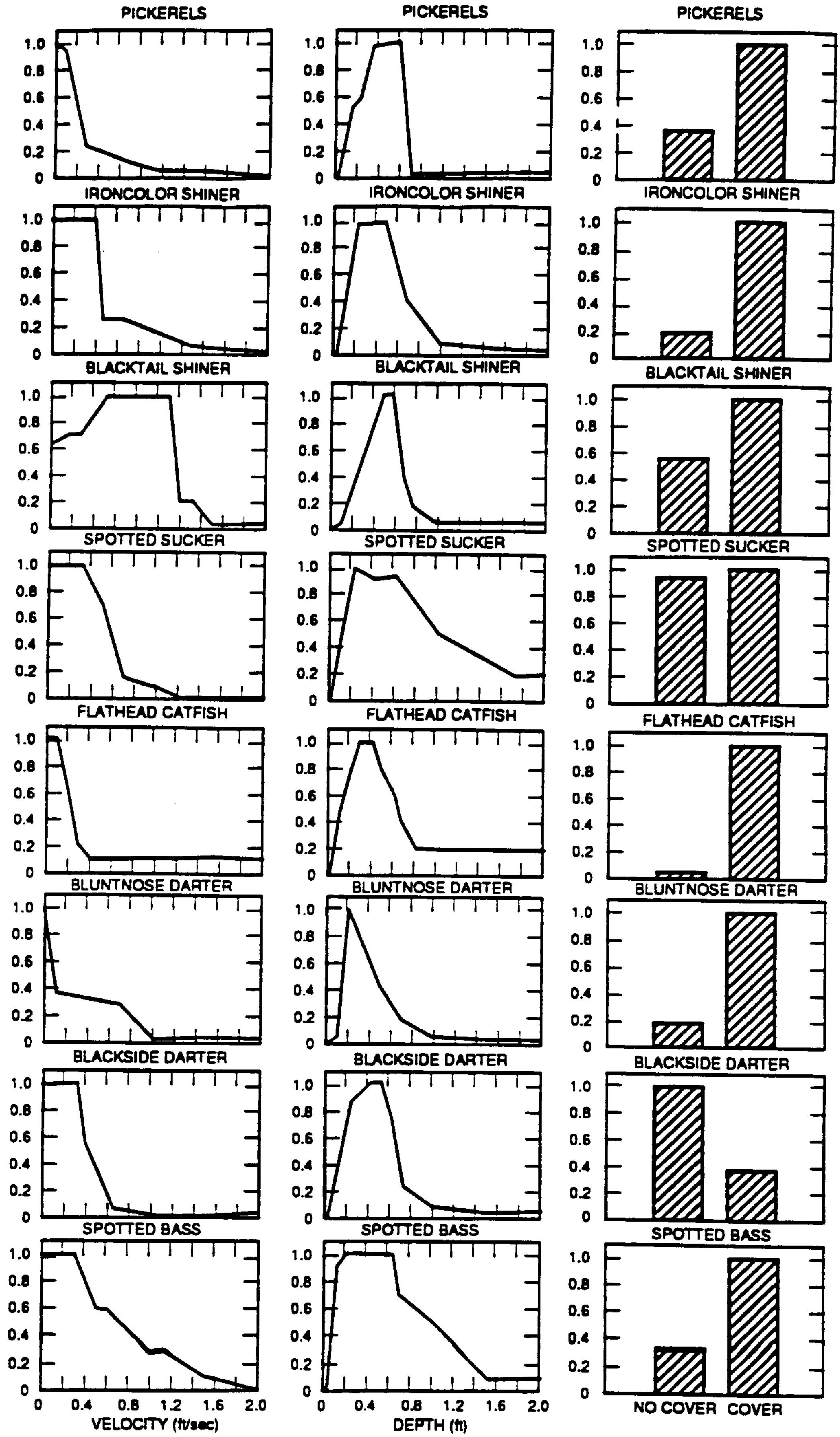
Changes in acres of stream fish habitat based on Instream Flow Incremental Methodology:

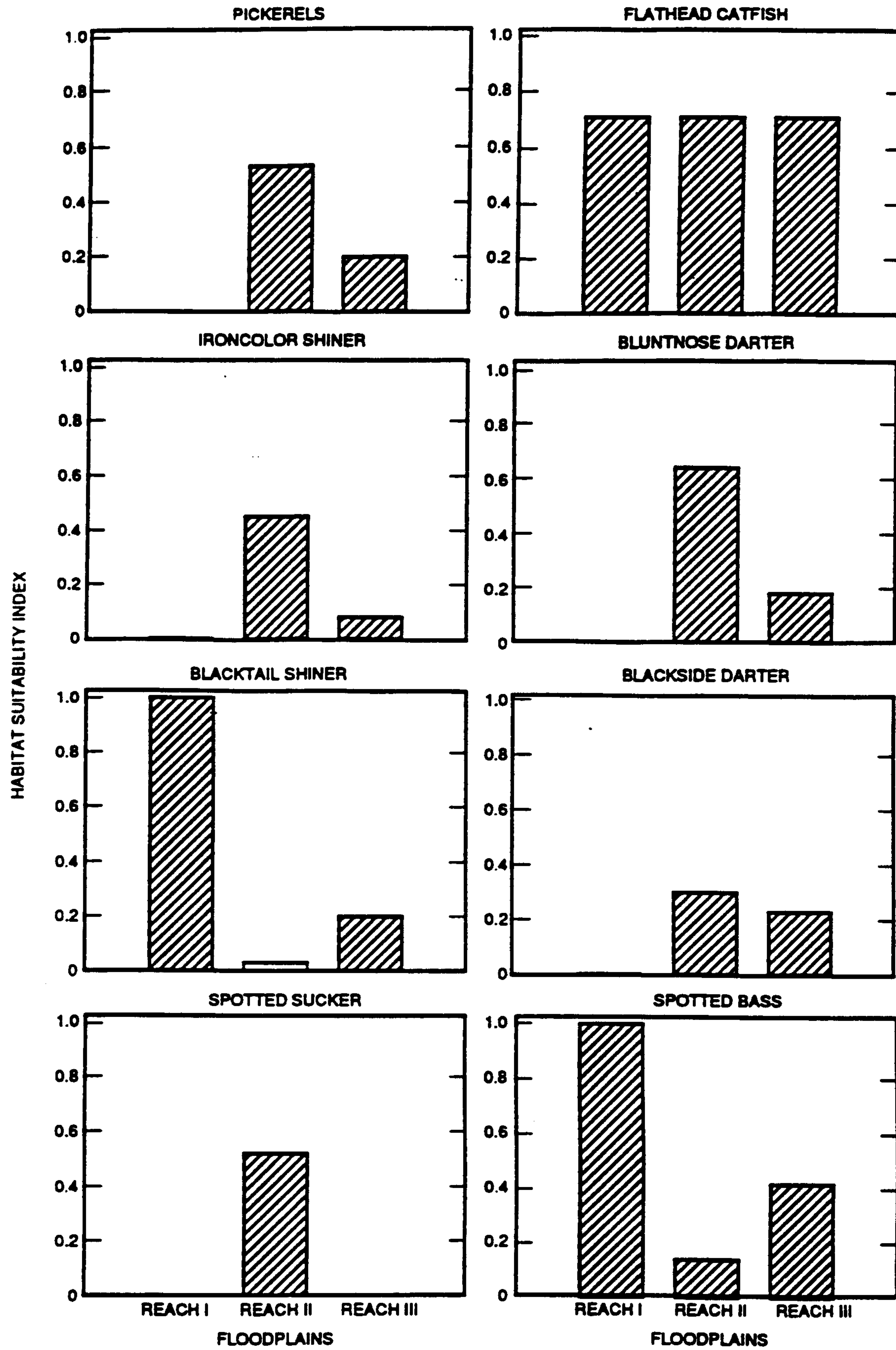
ACRES OF STREAM HARITAT

Reach	PICKERELS	SPOTTED BASS	SPOTTED SUCKER	IRONCOLOR SHINER	BLACKTAIL SHINER	BLACKSIDE DARTER	BLUNTNOSE DARTER	FLATHEAD CATFISH
I*	83	243	257	150	133	123	95	114
II	- 21	129	463	453	48	238	203	567
II	146	243	245	198	143	166	122	198
TOTAL	208	615	965	801	324	527	420	679

I Bared on discharges ≥ 900 cfs; post- ,preproject differences in acres assumed zero for lower discharges (Jul-Oct).


WIDTH
FEET
240
220
200
180
160
140
120
100
80
60
40
20
0
DEPTH
FEET
16
14
12
10
8
6
4
2
0
VELOCITY
FEET/SECOND
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
REACH I
REACH II
REACH III
TRIBUTARIES


PICKERELS
IRONCOLOR SHINER
BLACKTAIL SHINER
SPOTTED SUCKER
FLATHEAD CATFISH
BLUNTNOSE DARTER
BLACKSIDE DARTER
SPOTTED BASS
1.0
0.8
0.6
0.4
0.2
0
0
0.4
0.8
1.2
1.6
2.0
VELOCITY (ft/sec)
DEPTH (ft)
NO COVER
COVER


PICKERELS
FLATHEAD CATFISH
IRONCOLOR SHINER
BLUNTNOSE DARTER
BLACKTAIL SHINER
BLACKSIDE DARTER
SPOTTED SUCKER
SPOTTED BASS
HABITAT SUITABILITY INDEX
1.0
0.8
0.6
0.4
0.2
0
REACH I
REACH II
REACH III
FLOODPLAINS

43. Slight reductions in pickerel habitat occurred in Reach II, and these were confined exclusively to the fish habitat reach represented by the station at RM 55 (Marshall Pump Station). Habitat losses here were attributable to channelization within the original channel, and projected removal of extensive shallows and cover from the right shore. Habitat gains for most species reflect increases in habitat volume with minor, if any, reductions in habitat quality. The creation of a double channel in Reach II, and channel enlargement in other areas will more than offset reductions in cover and increases in depth.

44. Changes in flood plain fish habitat for a typical year (1985) are summarized below:

ACRES OF FLOW PLAIN HABITAT

Reach	PICKERELS	SPOTTED BASS	SPOTTED SUCKER	IRONCOLOR SHINER	BLACKTAIL SHINER	BLACKSIDE DARTER	BLUNTNOSE DARTER	FLATHEAD CATFISH
1*	D	-1768	0	0	-1768	D	0	-1255
II	-859	- 227	-842	-729	- 49	-486	-1037	-1150
III	- 205	-431	0	- B2	-205	-236	- 185	-728
TOTAL	*-1064*	- **2426**	**- 842**	**- -**	**- 2022**	**-722**	**-1222**	**-3133**

• Based on river stages- flood plain area curves for pre- and postproject conditions.

45. Because flood plain was reduced in all navigational reaches, habitat reductions occurred for all species. High habitat reductions (> 3,000 HU's) for flathead catfish resulted from the high SI (.71) applied to flood plains in all reaches; although few flathead were collected in this study, presence of this species was confirmed from all reaches. Habitat losses were high (> 2,000 HU's) for blacktail shiner and spotted bass since they occurred throughout the system but attained disparate abundance in the lower reach; habitat losses for the remaining species were lower because they were confined to the upper two reaches (< 1,300 HU'S). Zero values indicate that those species were not collected in that reach during the course of this study, and potential for wetland utilization is negligible.

MITIGATION REQUIREMENTS

46. Requirements for mitigation of fish habitat losses are based on maximum losses for any species, in any of the three principal habitats for each reach.

ACRES REQUIRED

REACH	RESERVOIR	STREAM	FLOOD PLAIN
I	0	0	1,768
II	0	21	1,150
III	0	0	728
TOTAL	0	21	3,646

47. Assuming no long-term, project-related changes in reservoir water quality, habitat losses were unmeasurable and mitigation will not be required. In streams, habitat losses occurred for pickerel only. Complete mitigation will be accomplished if 21 acres of channel habitat are created in Reach II with optimal conditions for this taxon (SI's - 1.00): no velocity, 3-6 feet depths, and abundant instresm cover. Sub-optimal conditions will require greater acreage. If _ considering the entire study area, however, mitigation for pickerel will be unnecessary since habitat gains in Reaches I and III overcompensate for the losses in Reach II. Flood plain habitat losses in Reach I occurred for blacktail shiner and spotted bass only; 1,768 acres provide complete mitigation for both species. In Reaches II and III, flood plain losses were greatest for flathead catfish; 1,878 acres will provide complete mitigation for all evaluation species.

MULTIVARIATE ANALYSES OF STREAM FISH DATA

48. Multivariate analyses were conducted to identify relationships between fish_ community structure and physical habitat. These techniques used data collected from stream surveys &scribed above. Unlike the IFIM, data from all species and for all habitat parameters were utilized. Such an approach allows direct habitat assessments for a greater number of species and objective determination of relative importance of different physical habitat factors.

49. Species diversity of fishes is positively associated with habitat quality (Gorman and Karr 1978; Foltz 1982) and water quality(Barbour and Brown 1974; Jackson and **Harvey** 1989; Keller and Crisman 1990), but the measurement of species diversity is problematic (Magurran, 1988). Typically "diversity" involves some _ evaluation of species richness (i.e., the number of species) and evenness (i.e., equitability of abundance among those different species). These components may be expressed separately or incorporated into a single measure (i.e., heterogeneity index). All assessments of diversity are influenced by ssmple-size, and for comparative purposes, sample effort or number of individuals should be the same.

50. Relationships between fish diversity and physical habitat are determined by correlating site-specific measures of fish diversity with habitat measurements. Those factors exhibiting high or significant correlations are presumed to influence the occurrence (richness) or abundance (evenness) of the greatest number of fish species, while those with low or nonsignificant correlations are presumed to influence fewer kinds of fish.

METHODS

51. Field methods were those described above. Fish abundance was expressed as the number of fish collected per 10 seine hauls.per site. Species-richness (S) was quantified as the number of fish species collected in 10 seine hauls at a site. A heterogeneity index,the Shannon function (H') was calculated that is sensitive to differences in species richness and evenness (Magurran, 1968). H' can range from 0.00, when a single species is present, *to* ln[total number of species], when species are all equally abundant. Although H' does not have an absolute upper limit, sample sizes and composition of small fish communities impose some constraints on observed values; for single collections of small stream fishes, usually H'< 3.00. Evenness (E) is the ratio of observed H' to maximum H' (for the observed number of species); values range from 0.00, when a single species is numerically dominant, to 1.00, when all species are equally abundant. For diversity and habitat measures, significant differences among locations or between seasons were determined using Student-Newman-Keuls test. Factors that were most closely associated with species diversity were identified by multiple regression, 0.15 significance level (SAS 1987).

RESULTS AND DISCUSSION

52. Water quality of Twelvemile Bayou differed from that of Cypress Bayou; mean pH and conductivity were higher (Figure 5). Variation in water quality parameters within locations and across time was lower for dissolved oxygen (Coefficient of variation - 6-22 percent) and Ph (CV - 6-26 percent) than for conductivity (CV -13-42 percent) and turbidity (38-89 percent). Mean Ph can be somewhat misleading since values represent a logarithmic scale, but it indicated a trend for more alkaline waters in the lower reach.

53. Sixty-four species were collected during this study (Table 6-2). Most were rare; 50 species were individually represented by fewer than 2 percent of all fishes collected. Numerically dominant species in order of abundance were: mosquitofish *(Gambusia affinis),* brook silverside *(Labidesthes sicculus)*, bullhead minnow *(Pimephales vigilax)*, bluegill *(Lepomis macrochirus), the* weed shiner *(Notropis texanus),* red shiner *(Cyprinellalutrensis),* threadfin shad (*Dorosoma petenense),* blackstripe topminnow *(Fundulus notatus),* longear sunfish *(Lepomis megalotis),* and ironcolor shiner *(Notropis chalybaeus*) . These species cumulatively comprised over 65 percent of 10,014 fish collected. Mosquitofish, brook silverside, bluegill, and blackstripe topminnow were common throughout the system. Threadfin shad and longear were less common in the tributaries. Weed and ironcolor shiners were absent from Twelvemile Bayou: red shiners were found only Twelvemile Bayou.

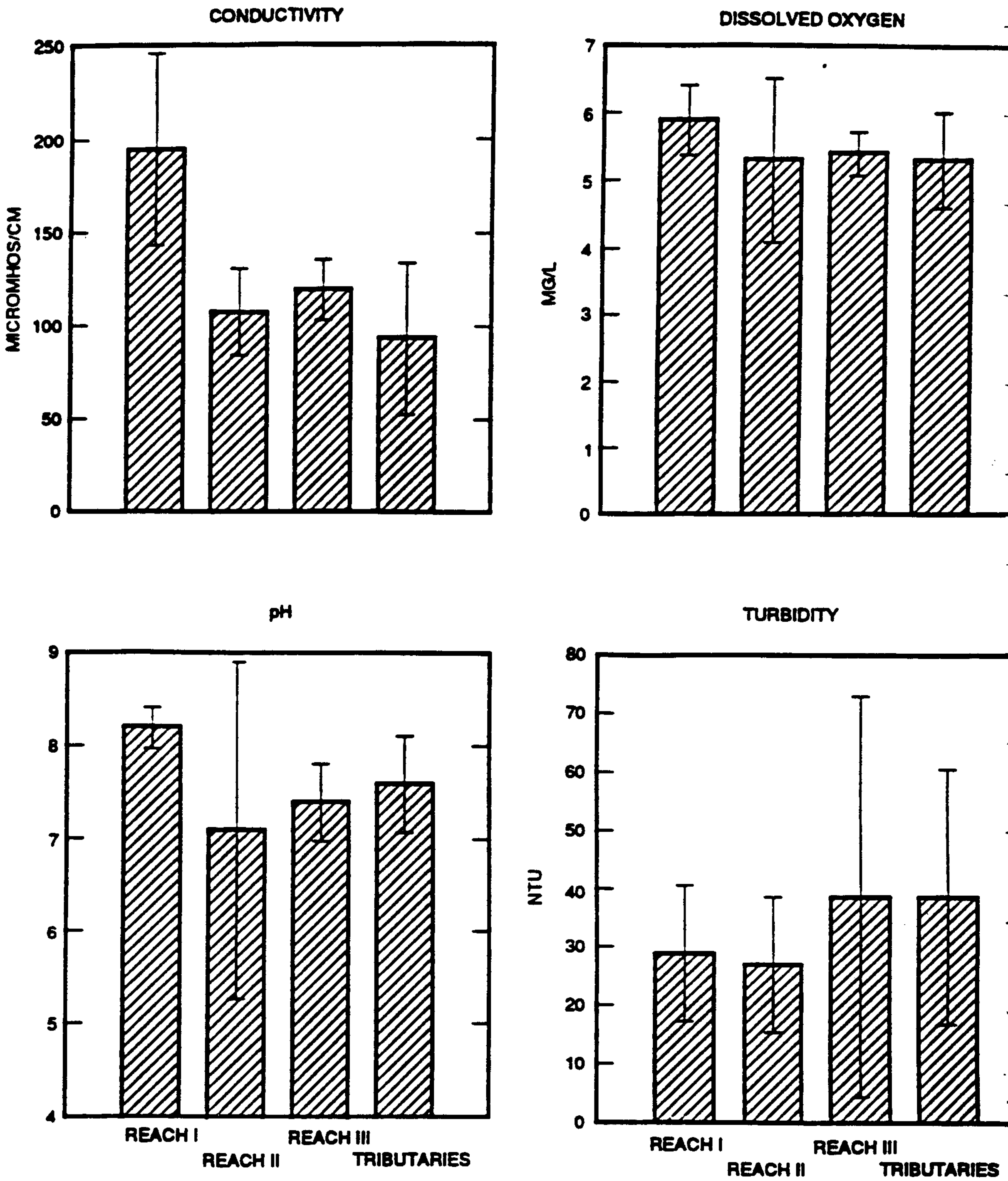

CONDUCTIVITY
MICROMHOS/CM
0
50
100
150
200
250
DISSOLVED OXYGEN
MG/L
0
1
2
3
4
5
6
7
pH
4
5
6
7
8
9
TURBIDITY
NTU
0
10
20
30
40
50
60
70
80
REACH I
REACH II
REACH III
TRIBUTARIES
REACH I
REACH II
REACH III
TRIBUTARIES

Table 6-2

Relative abundance of Cypress Bayou and Twelvemile Bayou fishes, April-August 1992: mean number/10 seine hauls/station. All species known are listed, including those not collected during this study.

Family/Species	Navigational Reach I	II	III	Tributaries
N -	7	19	12	15
Family Petromyzontidae				
Ichthyomyson castaneus, chestnut lamprey				
Family Lepisosteidae				
Lepisosteus oculatus, spotted gar		0.16		
L. osseus, longnose gar				
L. platostomus, shortnose gar				
L. spatula, alligator gar				
L. sp., juvenile		0.05		
Family Amiidae				
Amia calva, bowfin				
Family Anguillidae				
Anguilla rostrata, American eel				
Family Clupeidae				
Alosa chrysochloris, skipjack herring				
Dorosoma cepedianum, gizzard shad	0.43	0.05		
D. petenense, threadfin shad	13.43	5.21	13.92	0.07
Family Hiodontidae				
Hiodon alosoides, goldeye				
H. *tergisus*, mooneye				
Family Cyprinidae				
Cyprinella lurrensis, red shiner	53.85			
C. *venusta*, blacktail shiner	10.14	0.37	1.25	0.07
C. *lutrensis* X C. *venusra*, hybrid shiner	2.28			
Cyprinus carpio, common carp	0.14			
Hybognathus hayi, cypress minnow		0.05		0.07
H. *nuchalis*, silvery minnow	0.14			
Luxilis chrysocephalus, striped shiner	0.14			
Lytrurus fumeus, ribbon shiner	0.57	1.21	1.50	10.07
L. umbratilis, redfin shiner		0.16	0.17	0.40
Notemigonuscrysoleucas, golden shiner		0.42		0.07
Norropis amnis, pallid shiner		0.05		1.27
N. atherinoides, emerald shiner				
N. *arrocaudalis*, blackspot shiner				
N. *chalybaeus*, ironcolor shiner		6.84	1.25	5.13
N. *hubbsi*, bluehead shiner		6.95	0.08	
N. maculatus, taillight shiner			0.08	0.13
N. *stramineus*, sand shiner				
N. *texanus*, weed shiner		6.89	16.00	9.73
N. *volucellus*, mimic shiner				
Opsopoeodus emiliae, pugnose minnow		2.89	1.25	2.93
Pimephales vigilax, bullhead minnow	107.57	0.74	0.17	4.73

Table 6-2 (Con't)

Family/Species	Navigational		Reach III	Tributaries
	(7)	(19)	(12)	(15)
Family Catostomidae				
Carpiodes carpio, river carpsucker				
Erimyzon oblongus, creek chubsucker				
E. *succetta*, lake chubsucker		0.05		
Ictiobus bubalus, smallmouth buffalo				
I. *cyprincllus*, bigmouth buffalo				
I. niger, black buffalo				
Minytrema melanops, spotted sucker		0.63		0.80
Moxostoma poecilurum, blacktail redhorse				
Family Ictaluridae				
Ameiurus melas, black bullhead		0.26		
A. natalis, yellow bullhead		0.05		0.07
Ictalurus furcatus, blue catfish				
I. punctatus, channel catfish		0.95		0.07
Noturus gyrinus, tadpole madtom		0.21	0.08	0.93
N. nocturnus, freckled madtom				0.13
Pylodictis olivaris, flathead catfish	0.14			0.07
Family Esocidae				
Esox americanus, grass pickerel		0.95	0.75	0.60
E. niger, chain pickerel		3.16	0.92	2.07
Family Aphredoderidae				
Aphredoderus sayanus, pirate perch		2.95	0.83	2.07
Family Cyprinodontidae				
Fundulus chrysotus, golden topminnow		1.73		0.07
F. dispar, starhead topminnow		3.79	0.08	0.27
F. notatus, blackstripe topminnow	1.29	6.47	10.50	6.27
F. olivaceus, blackspotted topminnow				
Family Poeciliidae				
Gambusia affinis, mosquitofish	62.57	30.21	9.58	24.60
Family Atherinidae				
Labidesthes sicculus, brook silverside	59.86	20.47	40.83	11.60
Henidia beryllina, inland silverside	21.00			
Family Percichthyidae				
Morone chrysops, white bass				
M. *mississippiensis*, yellow baas				
M. *saxatilis*, striped bass				
M. *chxysops X saxatilis*, hybrid				

Table 6-2 (Cont)

Family/Species	Navlgatfonal I (7)	Reach (19)	III (12)	Tributaries (15)
Family Ccntrarchidae				
Cencrarchus macropcerus, flier				
Elassoma zonacum, banded pygmy sunfish		0.74	0.08	0.07
Lepomis auritus, redbreast sunfish				
L. cyanellus, green sunfish			0.08	0.07
L. gulosus, varmouth		2.00	0.17	0.67
L. humilis, orangespotted sunfish	0.57			
L. macrochirus, bluegill	3.14	22.89	17.75	2.87
L. margInatus, dollar sunfish		3.10	3.25	1.40
L. megalotis, longear sunfish	6.43	8.84	3.83	0.87
L. microlophus, redear sunfish	1.29	3.63	6.58	2.27
L. puncTatus, spotted sunfish	0.43	4.16	3.25	5.00
L. symmeTricus, bantam sunfish		1.10		0.27
L. punccacus X megalotis, hybrid sunfish		0.32	0.25	
L. SPP., juvenile sunfishes		34.53	8.33	2.47
icropterus punctulatus, spotted bass	3.14	0.42	0.92	0.27
M. salmoides, largemouth bass	1.43	5.84	3.33	0.80
Pomoxis annularis, white crappie		0.10	0.08	
P. nigromaculatus, black crappie			0.42	0.07
Family Percidae				
Ammocryp ta vivax, scaly sand darter	0.29	0.63	1.50	1.33
Etheostoma asprigene, mud darter		0.37	0.92	0.33
E. chlorosomum, bluntnose darter		2.63	1.33	5.60
E. fusiforme, swamp darter				
E. gracile, slough darter.				
E. hiscrio, harlequin darter		0.16	1.17	0.67
E. parvipinne, goldstripe darter				
E. proliare, cypress darter	0.29	3.26	1.33	7.47
E. whipplei, redfin darter				
Percina caprodes, logperch		1.47	2.00	1.00
P. maculata, blackside darter		1.63	1.08	1.80
Percina sciera, dusky darter	0.43		0.83	0.20
P. shumardi, river darter				
P. spp., juvenile darters		0.16		0.33
Family Sciaenidae				
Aplodinocus grunniens, freshwater drum				

54. Spotted sunfish *(Lepomis puncatus)*, ribbon shiner *(Lythrurus fumeus)*, cypress darter (*Etheostoma proeliare*) bluntnose darter (*E. chlorosomum*), pickerel (*Esox spp.)* blackside darter (*Percina maculata*), and logperch (*P. caprodes)* were moderately abundant (Table 6-2). These species cumulatively comprised 9 percent of fish collected but were common only in Cypress Bayou.

55. Abundance and community structure of fish assemblages were highly variable among sites, but significant differences among locations were not pronounced. Total number of fish/sample ranged from 25-1,025 individuals: richness ranged from 7-29 species, Shannon functions from 0.95-2.89, and evenness from 0,43-0.94 Abundance was significantly higher in the lower reaches than in upper Big Cypr Bayou and the tributaries (Figure 6). There were no significant differences among locations in species richness, but Twelvemile Bayou exhibited significantly lower diversity and evenness.

56. The wide ranges of community metrics, with few differences among locations reflected the substantial temporal changes in composition of the fish community. To compensate for this, we partitioned data into spring and summer data sets. Water temperature was significantly lower in spring (22° C) than summer (270 C), and total numbers of fishes were significantly lower in spring (124/sample) thar summer (290/sample).

57. Multiple regression analyses generated the following habitat-based models for richness and evenness components of species diversity:

Richness

Spring S = 26.243 + 0.167(Turbidity) l 0.027(Width) - 3.726(Velocity) - 0.922(Temperature) R^2 = 0.

Summer S = 21.583 + 0.033(Width) = 1.739(Dissolved oxygen) R^2 = 0

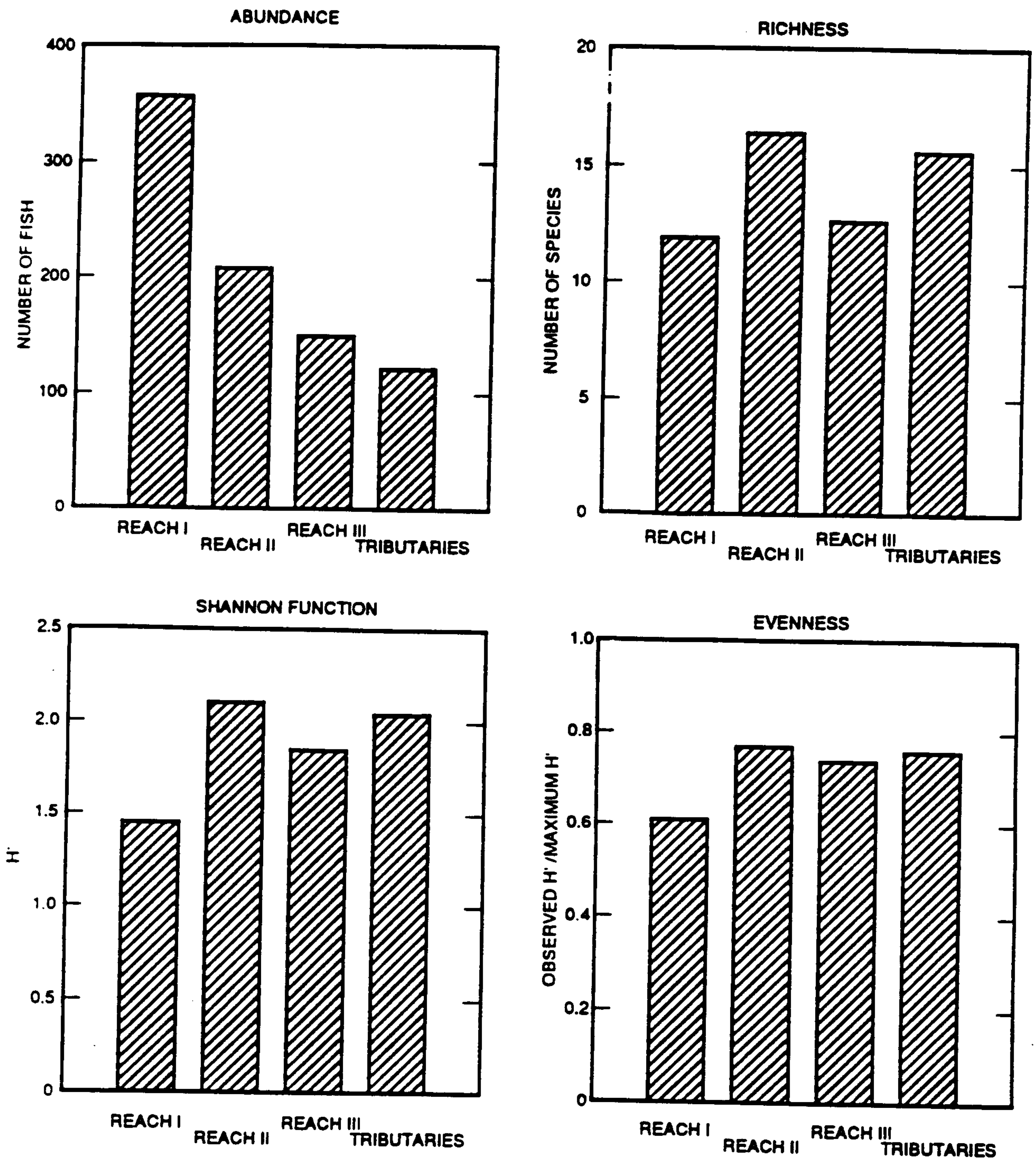
Evenness

Spring E = 0.866 - 0.001(Conductivity) R^2 = 0

Summer E = 0.692 - 0.039(pH) -0.001(Conductivity) - 0.019(Depth) R^2- 0,

58. These equations indicate that, in spring, greater numbers of species were found at turbid, wider channels in slower, cooler water: species were more equally abundant in waters of low conductivity. In summer, greater numbers of species were found at wider channels with lower dissolved oxygen; species were more equally abundant in waters of lower pH and lower conductivity, and at wider channels.

59. It appears counter-intuitive to find, during summer, greater numbers of species at lower concentrations of dissolved oxygen, and greater equitability in abundance at lower pH. Hypoxia (Dissolved oxygen < 4 ppm) and strongly acidic


ABUNDANCE
NUMBER OF FISH
400
300
200
100
0
REACH I
REACH II
REACH III
TRIBUTARIES
RICHNESS
NUMBER OF SPECIES
20
15
10
5
0
REACH I
REACH II
REACH III
TRIBUTARIES
SHANNON FUNCTION
H'
2.5
2.0
1.5
1.0
0.5
0
REACH I
REACH II
REACH III
TRIBUTARIES
EVENNESS
OBSERVED H' /MAXIMUM H'
1.0
0.8
0.6
0.4
0.2
0
REACH I
REACH II
REACH III
TRIBUTARIES

conditions (Ph < 6.5) were not recorded during this time. Also, it seems likely to assume that fish assemblages are adapted to these seasonally occurring conditions.

60. Different factors may influence diversity during different times of the year, but it is interesting to note that the models consistently identified a positive correlation between species richness and stream width, and a negative correlation between evenness and conductivity. If the proposed project does not affect the water quality parameters listed, and since width will increase, it is unlikely that species diversity would be adversely affected.

61. Channelization frequently results in higher turbidity (e.g., sediments washed in from unstable banks). In the Cypress Bayou and Twelvemile Bayou, turbidity is typically low to moderate (15-60 NTU's), but is an important correlate of fish community structure (this study; also see Killgore et al., 1991). Consequently, local fish assemblages could be particularly susceptible to any project-induced changes in turbidity, and impacts would be significant. If changes in any water quality parameter, especially turbidity, are predicted, a model incorporating hydraulic and water quality factors should be implemented (Killgore et al., 1991).

CONCLUSIONS

62. Ichthyofauna of the study area consists of more than 80 species and assemblages at individual stations are frequently complex. Diversity is correlated with hydraulic and water quality parameters.

63. Habitat losses for reservoir species are not anticipated.

64. Negative impacts to fish habitat in streams will be negligible. Evaluation species prefer slow, shallow water with cover. Although, channelization will increase depth and reduce cover within the navigation channel, the creation of a double channel in Reach II and channel enlargement in Reaches I and III will preserve high quality habitat and increase total habitat volume. Gross habitat gains were demonstrated for all species, presuming no significant change in other physical parameters (e.g., temperature, water quality).

65. Negative impacts to flood plain habitat will be substantial. Evaluation species mature in three years or less, so 2-year flood frequencies affect all generations; most actively exploit flood plains as spawning and rearing habitat..

66. Impacts on fish habitat are presumed irreparable for life of project. Mitigation requirements for the system are:

Reservoir	0 acres
Flood plain	3,646 acres
Stream	0 acres

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